Beneficial Management Practices for Wildlife Species at Risk on Agricultural Lands in Yukon




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Cover Photos:
Front cover: (top left) Soil-based agriculture is mostly limited to valley-bottoms and often close to major rivers: Yukon River valley (Maria Leung); (top right) Barn Swallow nestlings, close to fledging age, rest in a typical nest built close to an overhanging roof (Maria Leung); (bottom left) Little Brown Bat in flight (Bat Conservation International); (bottom right) The McKay's Western Bumble Bee is listed as Special Concern in Canada and found in Yukon (Syd Cannings)

Back cover: A male Rusty Blackbird holds a dragonfly nymph caught along the shore of a pond (Maria Leung).

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SUMMARY

The need to follow agricultural practices that are ecologically sustainable is increasingly evident given the current crises of climate change and biodiversity loss. Various approaches to agriculture, such as agro-ecology and diversified farming systems, aim to maintain the biodiversity that provides necessary ecosystem services for the farm economy at various scales, in contrast to the ecological simplification of intensive agriculture (Kremen et al. 2012). These approaches recognize that many native species provide vital ecosystem services and need to be conserved in agricultural landscapes.

In this context we propose a set of Beneficial Management Practices (BMPs) for conservation of a suite of wildlife species that live in Yukon's agricultural landscapes and that provide farmers with valuable ecological services of pest control and pollination. The species in question are all listed at risk under the Canadian National Species at Risk Act because of dramatic population declines in other parts of their range. These are three species of birds (Barn Swallow (*Hirundo rustica*), Bank Swallow (*Riparia riparia*), and Rusty Blackbird (*Euphagus carolinus*)), the most common bat in Yukon (Little Brown Bat (*Myotis lucifugus*)), and four species of bumble bees (Gypsy Cuckoo Bumble Bee (*Bombus bohemicus*), Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*), Yellow-banded Bumble Bee (*Bombus terricola*), and McKay's Western Bumble Bee (*Bombus mckayi*)). We have compiled the scientific evidence in support of these Beneficial Management Practices from the published literature and from our own field studies of the species in question undertaken in south Yukon's agricultural landscapes.

Some of the Beneficial Management Practices would benefit all the species concerned. The most prominent practice is keeping water bodies and streams (especially ponds and small lakes), with buffers of natural vegetation, out of agricultural land allocations so as to maintain their ecological functioning and habitat values. The agricultural landscape at large will then benefit from the services provided by the birds, bats, and bees that rely on the water bodies and adjacent vegetation but that also move widely within farms. Other comprehensively valuable BMPs include minimizing use of herbicides, pesticides, and fungicides, along with maintaining various and diverse components of the native vegetation (e.g., floral meadows, windbreaks, forest patches) within the matrix of cleared lands.

Most of the BMPs are targeted specifically at one or a few of these species-at-risk. Many focus on the need to find food. For example, bumble bees (and other native insects) feed on flowers of berry crops, providing valuable pollination services, but also require other flowering plants for nectar and pollen throughout the growing season. These complementary food sources can be provided by intercropping with flowering plants, and by retention of flower meadows. The success of these pollinators is put at risk by indiscriminate use of domesticated bumble bees and honey bees, species that can spread disease and outcompete some native pollinators. Barn Swallows benefit from easy access to livestock that attract concentrations of flying insects, some of which are pests that the swallows control. Little Brown Bats, Bank Swallows and Rusty

Blackbirds all feed intensively on the high concentrations of insect prey associated with intact wetlands and ponds, helping to control some of these insects that are pests (e.g., mosquitoes).

Many of the BMPs aim to provide shelter and secure sites for reproduction. Barn Swallows rely on human-made structures for nest sites; careful design and management of farm buildings can enhance their nesting. Little Brown Bats also often shelter in farm buildings. Provision of roosting structures can keep them active on farms especially when their use of specific buildings is a problem and has to be stopped. Bumble Bees can find adequate cavities for summer nesting and overwintering when small forest patches and windrows are retained close to crops to be pollinated.

Yukon's agricultural landscapes currently support all these targeted species at risk, and numerous other wildlife species. The historical pattern of land clearing, and the limitation of most soil-based agriculture to valley bottoms, have left many wetlands intact, many patches of forest among fields, and relatively short distances from most farms to intact forests on valley sides. These native species can continue to benefit farmers in the future, providing their services, given adequate application of these Beneficial Management Practices in the planning and care of agricultural landscapes through government-led land planning processes and through land stewardship by property owners. Yukon's agricultural sector can, at the same time, contribute significantly to ensuring a more sustainable future for these species.

1.0 INTRODUCTION

This document puts forward a set of Beneficial Management Practices (BMPs) regarding land and farm management so as to conserve some of the native wildlife species living on and using farmlands in Yukon. Although numerous species of wildlife can co-exist with farming, the focus here is on a set of species that have been assessed nationally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and found to be at some level of risk. Specifically, this set includes a mammal – the Little Brown Bat (*Myotis lucifugus*) considered "Endangered", and three birds: Barn Swallow (*Hirundo rustica*) considered "Threatened", Bank Swallow (*Riparia riparia*) considered "Threatened", and Rusty Blackbird (*Euphagus carolinus*) considered "Special Concern". It also includes a set of bumble bees: Gypsy Cuckoo Bumble Bee (*Bombus bohemicus*) considered "Endangered"; Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) considered "Threatened"; Yellow-banded Bumble Bee (*Bombus terricola*) and McKay's Western Bumble Bee (*Bombus mckayi*) considered "Special Concern". All these species perform useful, and sometimes crucial, services for farmers, mostly by way of crop pollination and pest control. The emphasis on tangible farm practices is meant to make the BMPs relevant to farmers, rural land owners, and land use planners.

Despite their national rankings being at risk, these species appear to be doing relatively well in Yukon. Compared to many other parts of the country, a larger proportion of Yukon landscapes remain intact and uncultivated, and Yukon agricultural lands are not as extensive because they are restricted to valley bottoms and maintain significant residual forest. This illustrates the key role that northern Canada can play in the future of these species at risk, and raises questions about how Yukon's agricultural landscapes may best be stewarded for these and other species in the future.

The document first provides some context on Yukon's agricultural landscapes, and on recent scientific findings and thinking about agricultural landscapes in general and their ability to jointly support certain native species along with crop and livestock production. The subsequent sections address the specific species, or species-groups in turn: birds, bats, and bumble bees. Within each section, there is a brief background on the species, followed by the Beneficial Management Practices themselves. The information on species biology is limited to facts that relate to the BMPs; there are already many websites and books available detailing the life history and ecology of these species. The literature that is cited in the text is compiled, for all sections together, at the end of the document.

The BMPs are structured as summary statements (bold text), followed by documented evidence from the literature, and a synopsis (in italics) of the results of our field work on agricultural lands in southern Yukon that are relevant to the specific Practice. These results are still in the process of being published in the scientific literature, so are sometimes referred to as "unpublished data". We include photos taken in southern Yukon by ourselves, unless otherwise indicated. These illustrate useful application of as many of the BMPs as possible.

2.0 CONTEXT

2.1 Agriculture in Yukon

Agriculture is a relatively small and restricted use of land in Yukon, amounting to about 15,500 ha of private land designated for agriculture, and about 9,600 ha of grazing leases on public lands (Government of Yukon 2018). In addition, rural property owners whose lands are not registered farms can clear land for agriculturally related purposes. Mountainous landscapes limit suitable terrain to the larger valley bottoms. Glaciers scoured southern Yukon as recently as about 13,000 years ago, so soils are young and often nutrient poor. A cold, subarctic climate restricts the length of the growing season and the rate of decomposition of organic materials for soil development (Smith et al. 2004).

Agriculture's small total footprint on the land does not adequately represent its impact, however. This is because it is constrained to valley bottoms that are also the most productive landscapes for forest and wetland ecosystems. Removing or impacting these ecosystems by permanently clearing land necessarily results in a reduction in habitat for numerous species. A more reasonable measure of agriculture's impact would be the proportion of valley bottom lands that are occupied by agricultural activities – both cleared lands and grazing leases.

Soil-based agriculture is mostly limited to valley-bottoms and often close to major rivers: Yukon River valley (Maria Leung).

Agriculture in Yukon is growing in spatial extent, diversity of activities, and investment. The latest statistical summary is from the 2017 census (spanning change from 2011 to 2016), and shows a 9% increase in number of farms, including increases in the total areas growing hay which is the most extensive crop (3%), vegetables (50%), and berries (100%) (Government of Yukon 2018). Livestock numbers also increased: cattle (15%), pigs (760%), and poultry (89%). The Yukon Government has led the development of a Local Food Strategy (Government of Yukon 2016) that advocates substantial investment in improving availability of new farmland, access to equipment and infrastructure for local food processing, education, and field testing of novel crops. Various government funding programs, notably the federal Canadian Agricultural Partnership investments, have provided capital for numerous projects (Government of Yukon 2018). These patterns continue today.

The drivers of these increases in agricultural activity are varied. A warming climate is creating improved growing conditions for some crops (King et al. 2018). The human population, especially in Whitehorse, is growing rapidly, creating more local demand (YBS 2022). Most food is imported from the south by road, a supply route that can readily be disrupted by fire or flood and that has a high carbon footprint, suggesting the need for more local supply (Government of Yukon 2016). Some southern sources of produce, such as California, are increasingly at risk in a changing climate (Pathak et al. 2018), also indicating the need for more local supply. Various First Nations have invested in their own community-run farms to increase their food sovereignty and security (Government of Yukon 2020). Overall, there is growing interest in local food security in a more risk-prone world (Government of Yukon 2016, 2020). This trend in Yukon is part of growing interest in agriculture in boreal forest regions globally (King et al. 2018, Seguin et al. 2022), and stimulates questions about how to manage or steward the necessary agricultural production while maintaining the agricultural services provided by various native species and not putting all valley-bottom ecosystems at risk.

The most extensively grown crop is hay. This hay field includes portions fallow and summer harvested (Donald Reid).

2.2 The Search for Ecologically Sustainable Agriculture

Farms are managed portions of ecosystems. Farmers are actively influencing or controlling various components of the relatively simple system they have created so that crop and livestock yield can be improved. At the same time, many native species living on and near farmland are providing services for farmers that enhance the production of crops and the health of livestock. These include insects pollinating crops, and various birds, mammals, and insects eating pests whose populations can reduce the productivity of crops and livestock. The challenge lies in understanding the dynamics of these processes so that the full farm ecosystem can be managed sustainably, which includes persistence of as many native species as possible.

Proposing Beneficial Management Practices for conserving some wild species in agricultural landscapes, as we do in this document, is built on the assumption that farmlands have the ability to support a remarkable array of native species – plants, insects, amphibians, birds and mammals. Farms are not just simple fields of single crops, and land cleared for livestock. Farms can, and often need to, include habitats for numerous species that benefit the crops and livestock, and farms can also include habitats for a wider variety of species. That wider variety of species clearly cannot include all species living on the land before it was turned into farms. Species dependent on water bodies, wetlands, and the adjacent riparian shrubs and forests will not do well when riparian vegetation is cleared. Species relying on extensive upland habitats, especially forests, will not do well when land is cleared. Consequently, ecological sustainability requires zoning of different land uses in land planning. Some valley-bottoms need to be zoned for wild ecosystems, and some zoned for agriculture though with the exclusion of water bodies and wetlands plus their buffers of sufficient shrub and forest to sustain associated species. Segregation of land use functions, including agriculture, through such strategic land use planning is a crucial step for ecological sustainability regionally.

Within agricultural zones, we need to follow agricultural practices that are ecologically sustainable. Few farms are likely to be complete ecosystems because they require ongoing flows of nutrients, water, seeds and livestock in and out; they are not self-perpetuating systems. However, the various efforts around the world to make agriculture more sustainable generally involve retaining as much of the original biodiversity as possible. The goal is to make the individual farm or the agricultural landscape as complete a self-perpetuating ecosystem as possible (Francis and Porter 2011, Vandermeer 2011, Kremen et al. 2012). These efforts are often lumped under the term agro-ecology, and include regenerative agriculture, permaculture, organic agriculture, diversified farming systems, and agroforestry. Collectively, these are a response to the demonstrably unsustainable model of intensive agriculture that has increasingly dominated global food production in the late twentieth and early twenty-first centuries (Vandermeer 2011, Kremen et al. 2012).

One characteristic of more intensive agriculture (this is Alberta) is large fields with single crops and very little retention of native vegetation along field edges (Donald Reid).

Intensive agriculture refers to higher crop or livestock yield per unit area (Douglas et al. 2018). Higher yield is associated with higher use of agrochemicals (such as fertilizers, pesticides, and herbicides), increased mechanization, increased irrigation, reduced extent of natural vegetation, more homogeneous farm landscapes, and less fallow land, which together decrease availability of insect prey and habitat for various life history needs of numerous species (Wickramasinghe et al. 2003, Heim et al. 2015, Monck-Whipp et al. 2018, Put et al. 2019, Sánchez-Bayo and Wyckhuys 2019, Traba and Morales 2019, Hendershot et al. 2020, Raven and Wagner 2020, Maslo et al. 2022), and increase pollution (Khanna and Gupta 2018, Withers et al. 2020) while degrading soil quality (Vandermeer 2011).

The Beneficial Management Practices that we describe here fit within the agro-ecological approach. Their aim is to keep as complete a set of native species as possible on farms. The species at risk that we focus on here perform ecological functions that are a direct benefit or service to farm production. For the sake of their conservation and avoidance of pollution, the role of these species should not be replaced with imported species or agrochemicals.

3.0 BENEFICIAL MANAGEMENT PRACTICES FOR THREE SPECIES OF BIRDS

The following literature review on birds is specific to Barn Swallow, Bank Swallow, and Rusty Blackbird. These are species at risk that either have high likelihood of nesting on farms or are known to occupy habitats in the lowlands where most conversion of land to soil-based agriculture has occurred in Yukon.

3.1. Barn Swallow

3.1.1. Background

The Barn Swallow is considered "threatened" under the Canadian Species at Risk Act (SARA). For species listed under SARA, the Barn Swallow (*Hirundo rustica*) is unusual in that it is best known as an inhabitant of human-made structures on farmland. Most other species at risk have not co-existed so closely with humans for so long. The abundance of Barn Swallows is strongly associated with livestock farming, especially cattle and dairy farming (Ambrosini et al. 2002, 2011). Traditional buildings not only have structures upon which to build nests, but the warmth generated from the livestock shelters the nests from cold temperatures, improving nestling survival (Grüebler et al. 2010, Møller 2001). Hay fields and pastures associated with livestock husbandry also support a greater abundance of insect prey than intensive agriculture such as row crops (COSEWIC 2011). Swallows in general contribute to control of insect pests. Swallows are aerial insectivores with a wide diet breadth, catching insects while flying in the air. Swallows will readily forage on pest insects as these become available (Orlowski et al. 2014).

(Left) Farm yard structures provide perches for resting adult Barn Swallows (Maria Leung).

(Right) A pair of Barn Swallows has taken advantage of a horizontal structure close to an overhanging roof to build a nest, and will take turns incubating the eggs (Donald Reid).

The decline in the global population of Barn Swallows has been documented in Eurasia and North America. Factors contributing to the decline include: a change from mixed livestock/crop farming, associated with heterogenous landscapes, to intensive agriculture focussed on a few cash crops which results in relatively homogenous landscapes; the conversion of wetlands to cultivated lands (Jobin et al. 1996, Latendresse et al. 2008); change in the type of building structures associated with foraging habitats (COSEWIC 2011); and a decline in prey availability (Turner 1991, Basili and Temple 1999, Nebel et al. 2010).

3.1.2. Beneficial Management Practices

- **Maintain or create strips of native vegetation beside water bodies and wetlands.** Leaving or creating buffer strips along waterways and wetlands (Best 2000, Koford and Best 1996) maintains the ecological functioning of these aquatic habitats and so ensures an ongoing source of insect prey for Barn Swallows and other aerial insectivores. For Barn Swallows, having this habitat within 500m of nest sites is of particular value. Studies have found that most of their foraging effort is within this distance of their nest site (COSEWIC 2011). *In Yukon, the farms with highest number of nesting pairs of Barn Swallows were immediately adjacent to lakes, ponds, and wetlands (Leung, unpublished data).*
- **Create new aquatic habitats on farms.** Human-made aquatic habitats on farmland can be in the form of drainage ditches, designed to accumulate water, or small ponds (Lamoureux and Dion 2019). These provide habitats for a diversity of plants and animals, including the aquatic life stages of insects that, as adults, fly and become prey for aerial insectivores such as Barn Swallows.

(Left) Retention of even a partial or narrow strip of native vegetation between field and wetland supports wetland functioning including production of aquatic insects that fly as adults and are Barn Swallow prey (Donald Reid).

(Right) When the water table is close to the ground surface, excavations can create new ponds that are water sources for livestock and native species, and habitat for aquatic insects on which Barn Swallows feed (Maria Leung).

- **Maintain livestock with outdoor pastures within about 500 m of buildings and structures where barn swallows nest.** Pastures provide habitat for various life stages of insect prey for insectivorous birds. In Europe and North America, there has been a general move away from cattle farming with pastures, and a move towards the production of crops on arable land (e.g., cereals) (COSEWIC 2011). This intensification, or homogenization, of agriculture has reduced the availability of insect prey for birds. Arable crops often require synthetic fertilizers and pesticides (Evans and Robinson 2004). These crops also come with a loss of the rich aerial insect fauna associated with grazed grass (Evans 2001, Ambrosini et al. 2002, Murphy 2003). Intensive agriculture also tends to keep some livestock, notably pigs and chickens, indoors. Livestock manure heaps, outside in farm yards and pastures, enhance the food supply for swallows by providing a suitable substrate for coprophagous insects to proliferate (Grüebler et al. 2010). Including pastures and fenced areas for livestock within 500 m of Barn Swallow nests within a farming scheme would provide suitable foraging areas.

(Left) Barn Swallows have built their mud nest on a rafter above a hay rack for feeding goats (Maria Leung).

(Right) An open-sided pig barn is an excellent potential nesting space for Barn Swallows, and a wooden nest cup attached to a joist provides a future nesting site (Maria Leung).

A mix of forest stands, hedgerows, crop fields, pasture, unmanaged grasslands, wetlands and water bodies in close proximity provides excellent structural diversity for foraging Barn Swallows (Maria Leung).

Barn Swallows build their nests with local vegetation cemented together with mud, which adheres to various surfaces (Maria Leung).

- **Include farming practices that promote a structural diversity of vegetation in space and through time across the agricultural landscape.** Having vegetation of varying heights increases insect species diversity (Grüebler et al. 2008). Features such as hedgerows, windbreaks and groves of trees improve the diversity and abundance of prey and are known to accumulate insects during adverse weather conditions (Benton et al. 2002, Evans and Robinson 2004, Grüebler 2010, Orlowski et al. 2014). Leaving areas uncultivated, intercropping, and having a greater mix of crops, all support a higher diversity of birds on farmland (Kirk et al. 2011).
- **Provide mud close to possible nest sites during spring and early summer.** Barn Swallows require mud to build their nests, and the availability of mud within a short distance of potential nest sites may limit their ability to nest (Barclay 1988, Kigore and Knudsen 1977). *In Yukon, all barn swallow nests were built with a large proportion of mud, and the mud was readily available in the associated farm property close to the nesting site (Leung, unpublished data).*
- **Avoid the use of pesticides and herbicides wherever possible.** Both herbicides and insecticides lower the quality of habitat for birds that hunt in open areas due to a reduction in habitat quality for insects and direct mortality of insects (Kirk et al 2011). Large-scale declines in insect prey have been implicated as a contributor to declines in aerial-foraging insectivores, including the Barn Swallow (COSEWIC 2011, Evans *et al*. 2007).

- **Protect nests from predators where possible.** Lamoureux and Dion (2019) recommended the avoidance of machinery, tools and materials within 180 cm around and below occupied nests to reduce predation by cats and other predators. Slippery material such as metal flashing can also be nailed adjacent to and below nests to deter predators (Daly 2002). *In Yukon, some nesting Barn Swallows lost eggs to magpies and deer mice, and some nestlings were predated by cats (Leung and Reid, In press).*

Domestic cats, deer mice, and Black-billed Magpies were recorded predating Barn Swallow nests on farms in south Yukon. The deer mice and Magpies primarily consumed eggs, and the cat was able to reach nestlings (Maria Leung and Donald Reid).

- **Maintain nesting opportunities in and on buildings and other structures made by people**. Barn Swallows are known to nest in and on a wide variety of buildings and structures made by people. These include barns, sheds, and houses. Generally, the birds select sites that are relatively sheltered, from bad weather and predators. So, they often nest inside the buildings, and always close to a roof or ceiling. To nest inside buildings, some flying route through a door or window has to be open all the time. Some farm buildings not previously used might become suitable nesting sites if openings were created for permanent entry and exit. *In Yukon, Barn Swallows use a wide variety of structures that can provide shelter. These include the inside of large and small barns with solid walls, livestock and other sheds with solid walls, garages, and open-walled structures to house hay and farm machinery. Close to 50% of nests we monitored over two years were inside buildings with closed walls. The swallows also successfully nested on the outside of buildings under eaves, covered porches, and decks (Leung and Reid, In press).* The swallows are also known to repeatedly use nest sites year after year, so these buildings or structures, and the nest sites they

Barn Swallows frequently nest close to the roof inside farm buildings with permanent openings such as this pig barn (Donald Reid).

offer, appear to be necessary for the birds. *In Yukon, Barn Swallows often re-use previously built nests for a number of years after first built. They also build new nests within a few metres of other nests, in successive years, when the structure provides a suitable site to support a new nest (Leung and Reid, In press).* For the actual nest site, the swallows require a surface that can support a nest made of mud mixed with vegetation and often livestock hair. The site is almost always close to an overhanging feature such as a roof, ceiling, or soffit. They often choose a horizontal surface, even a small one, such as a rafter, window frame, or top of light fixture. They also successfully build nests on near-vertical walls. Porous material such as wood without paint offers adequate adhesion for mud nests. Nests built on vinyl or metal siding, or painted wood, have higher risk of falling. Modern farm buildings, for example barns, are increasingly built of metal, and may have fewer suitable surfaces on which to build nests. This has been implicated as a factor in declines of Barn Swallows in some agricultural regions (COSEWIC 2011). *In Yukon, Barn Swallows were found to build nests at a wide diversity of sites with a well-protected horizontal feature such as rafters, beams, light fixtures, metal frames of tents and shelters, and the frame of a transport trailer. On the outside of buildings, nest sites included wood siding, window frames, window blind, porch rafter, and light fixtures. Some nests adhering to vertical surfaces were successful, but two failed to stick to the surface so the nesting attempt failed. This raises the question of whether people could provide new nest sites with some kind of horizontal structure. Barn Swallows successfully nested in modern metal barns, but they had some internal horizontal framework on which the birds could build a nest (Leung and Reid, In press).*

- **Provide new nesting structures or small-scale nesting sites.** Barn Swallows are known to nest in other structures such as bunkers (Zduniak et al. 2011), and on platforms or nest cups designed specifically for them (Daly 2002, OMNRF 2016). *In Yukon, our short-term attempts to provide Barn Swallows with new nesting structures were unsuccessful. Barn Swallows did not complete any nests on nesting platforms (two years) or wooden nest cups (one year) placed on or in farm buildings. Instead, new nests were built on pre-existing structures such as rafters. However, one farmer built a simple horizontal platform to encourage a pair of Barn Swallows to move their nest site slightly, and it was successful (Leung and Reid, In press).*

(Left) Barn Swallows successfully nested on a platform provided by a property owner to divert them from nesting on the window blind (Maria Leung).

(Right) Wooden cup-shaped structures in the general shape of a Barn Swallow nest have been used successfully by Swallows in some jurisdictions. The birds started to build a nest on this one in Yukon (Maria Leung).

3.2. Bank Swallow

3.2.1. Background

The Bank Swallow is currently listed as “threatened” under the Canadian Species at Risk Act. It is widely distributed across Yukon. It is most often associated with major rivers where vertical banks of silt, clay or sand are available for excavating nesting burrows. Nesting birds tend to be colonial with multiple nesting pairs at one cliff or bank. In Yukon, nesting colonies have also been found in cut banks along roads (Sinclair et al. 2003) and, rarely, in quarries for aggregates (sands and gravels) (Sinclair pers. comm.). Artificial habitats, such as quarries, are frequently used in other parts of Canada. In Ontario, the prevalence of Bank Swallow colonies in quarries warranted guidelines to accommodate the bird’s nesting needs where aggregate materials are excavated (OMNRF 2017).

Only some of the numerous burrows in a Bank Swallow colony are occupied in any one season, and an observer has to watch for considerable time to see whether birds come and go from any one burrow (Pamela Sinclair).

Bank Swallows begin arriving in Yukon in mid-May and have departed by mid-September. Nesting begins late May and may last as late as early August (Sinclair et al. 2003). Bank Swallows often return to the same nesting site as previous years (Garrison 1999). Although nesting habitat often dominates considerations of Bank Swallow persistence, foraging habitat also contributes significantly to their reproductive success. Foraging areas are usually open habitats such as wetlands, lakes, rivers, and agricultural croplands (Garrison 1999). Many farms in southern Yukon are adjacent to major rivers with nesting colonies and so are potential feeding grounds for Bank Swallows. The Yukon River between Marsh and Laberge Lakes supports many nesting colonies close to agricultural land (Sinclair et al. 2021) as does the Takhini River.

As is the trend for many other aerial insectivores, the population of Bank Swallows has been severely reduced. In the past 40 years, the Canadian population has experienced a >90% decline. Factors contributing to the decline include loss of breeding and foraging habitat, widespread pesticide use and resulting reduction in insect prey, and destruction of nests during aggregate excavation.

Existing Beneficial Management Practices (BMPs) in Canada focus on threats to nesting habitat, including human-made nesting habitats such as quarries. In the context of Yukon agriculture, fields as foraging habitat are more relevant for BMPs than nesting habitats. Nesting habitats are rarely within the boundaries of designated agricultural land in Yukon but are frequently close to agricultural lands that may provide foraging habitat.

3.2.2. Beneficial Management Practices

- **Maintain and protect the current set of known sites with nesting colonies.** The availability of suitable substrates limits where Bank Swallows are able to nest. They require eroding vertical banks made of substrates like silty sands and clays that the birds can excavate. If such nesting habitats are available on or adjacent to agricultural lands, there are guidelines to protect them (OMNRF 2017). OMNRF (2017) recommends minimal disturbance by machinery and people during the breeding season (mid-May through mid-August in Yukon). OMNRF (2017) also provides guidelines on managing vegetation to ensure the persistence of the site, but this is better undertaken by a professional experienced with Bank Swallow habitat (e.g., Canadian Wildlife Service). *In Yukon, Bank Swallows nest at 37 colonial sites along the Takhini River where it flows through the agricultural landscape downstream of the Alaska Highway. We have documented these sites as eBird records for future reference.*

(Left) Bank Swallows excavate nesting burrows in the compacted sands and silts of exposed bluffs, often adjacent to rivers. The numerous burrow entrances can be seen as holes of various sizes on this bluff along the Takhini River (Donald Reid)

(Right) Two Bank Swallows approach a colonial nesting site in a river bluff with numerous entrances to nesting burrows (Donald Reid)

A Bank Swallow colony along the Takhini River (foreground) is close to a diversity of insect prey associated with the river, adjacent wetlands, natural grasslands, forest groves, pasture, and hay fields (Maria Leung).

- **Maintain a diverse set of open wetlands plus meadow and/or cropland habitats for feeding.** The abundance and quality of insect prey can limit breeding success of Bank Swallows. Starvation has occurred during poor weather when the insect prey that Bank Swallows rely on become unavailable (COSEWIC 2011). Foraging habitat can be created by vegetation management to promote grass and wildflowers in openings and by deterring invasive plants (Bank Swallow Technical Advisory Committee 2013, OMNRF 2017).
- **Avoid the use of pesticides and herbicides wherever possible.** Abundance of insect prey can be improved by avoiding the use of pesticides. Insecticides, herbicides or fungicides contribute to the reduction of insect prey. Bank Swallow presence is negatively correlated with use of herbicides (Kirk et al. 2011).
- **Consider the creation of new nesting sites through the digging of banks in suitable substrates**. Bank Swallows readily use human-made nesting sites meeting their requirements (COSEWIC 2013). Preferably, the site would be as near vertical as possible, with a dimension >30 m long and 0.5 to 20 m high to minimize predation risk. For excavating nesting burrows, a soft substrate of sand, silty sand, or loamy sand is needed. Close proximity and orientation to foraging habitats are also useful attributes of a potential nesting site (OMNRF 2017).

3.3. Rusty Blackbird

3.3.1. Background

(Top) A male Rusty Blackbird with the aquatic larva of an insect captured in shallow water (Syd Cannings)

(Bottom) A female Rusty Blackbird (top) with two recently fledged young (Donald Reid).

The Rusty Blackbird is classified as a species of "special concern" under the Canadian Species at Risk Act (Environment Canada 2015). It breeds in wooded wetlands of the boreal forest. In Yukon, Rusty Blackbirds begin arriving in mid-April. Nests with eggs in Yukon have been found late May through mid-June (Sinclair et al. 2003). The nest is usually constructed in small stunted conifers close to shallow open water. Surrounding vegetation is often thick, offering cover from potential predators (Powell 2010a). Nesting in such trees and locations may be an adaptation to avoid predation by red squirrels and corvids (DeSanto and Willson 2001, Powell 2010a). Nests in interior Alaska have also been found in willows close to water (Matsuoka et al. 2010a).

Both parents bring food to nestlings (Avery 2013). Foods include large aquatic insects such as dragonfly larvae, spiders, molluscs, and small fish (Greenberg and Matsuoka 2010, Matsuoka et al. 2010b). By early August, fledging is complete, followed shortly by migration. Fall migration peaks late August to early September, although stragglers have been reported as late as December (Sinclair et al. 2003).

The Rusty Blackbird has experienced among the most dramatic declines of passerines in North America, with an estimated population reduction of >80% since 1966 (Greenberg et al. 2011). Known threats include degradation of habitat in wintering grounds due to conversion and hydrological alteration of bottomlands, plus direct mortality from programs intended to reduce problems with various blackbirds feeding on agricultural crops (Greenberg and Droege 2003, Greenberg and Matsuoka 2010, COSEWIC 2014). Other possible contributing factors to the decline include mercury contamination from pollution and wetland acidification, degradation of breeding habitat including forest clearing, drying of wetlands in a warming climate, altered composition of the predator and competitor communities, disease, and parasites (COSEWIC 2014). Of these contributing factors, the one most pertinent to Yukon agriculture is the loss of wetlands and associated nesting habitats.

3.3.2. Beneficial Management Practices

- **Maintain or create strips of native vegetation beside water bodies and wetlands that already have high suitability as nesting habitat**. Powell et al. (2010b) suggest a 75m buffer of undisturbed vegetation around wetlands where timber harvesting close to wetlands would increase exposure of Rusty Blackbirds to predation by red squirrels and corvids. An effective buffer width in agricultural landscapes may differ from the 75 m suggested for forested landscapes. Forest dwelling animals such as red squirrels would pose less risk where land has been permanently cleared, uphill of the buffer, for agriculture. The most straightforward way to maintain Rusty Blackbird nesting habitat, as well as many other wetland values, is to keep ponds and small lakes out of agricultural land allocations (and fenced where livestock use adjacent fields). These exclusions would include the water body and an upland buffer above the ordinary high water mark. The Forest Resources Regulation regarding riparian retention (Government of Yukon 2011) provides some guidance on buffers, but requires added interpretation. It only addresses lakes larger than 1 ha in surface area, but Rusty Blackbirds frequently nest close to and forage around smaller water bodies (Matsuoka et al. 2010a, b). It also supports varying width (40 – 100 m) of retention with some forest harvesting allowed. We recommend applying buffers associated with the smallest lake class (1-3 ha) to all small water bodies in agricultural zones, and unharvested buffers of erect woody shrubs and trees at least 50 m wide (the radius around open water used in many northern nest searches, Matsuoka et al. 2010a, b). *In Yukon, a survey of waterbodies (sizes c. 0.3 to 2.0 ha) in or close to agricultural lands during the nesting season only detected Rusty Blackbirds where natural riparian vegetation, including forest, was retained around the majority of the waterbody. Waterbodies where Rusty Blackbirds were residing had mature conifer, or mixed conifer-deciduous forests in the majority of the riparian zone. Rusty Blackbirds were not observed by waterbodies surrounded principally by herbaceous vegetation where forested riparian was largely absent (Leung unpublished data).*

Smaller-sized water bodies with wide buffers of spruce and willow provide high value Rusty Blackbird habitat (Maria Leung).

4.0 BENEFICIAL MANAGEMENT PRACTICES FOR LITTLE BROWN BATS

4.1 Background

The Little Brown Bat, or Little Brown Myotis, is classified as "endangered" under the Canadian Species at Risk Act. The species has suffered precipitous population declines, especially in eastern North America, largely from infections of the fungus causing white-nose syndrome (Environment and Climate Change Canada 2018). This fungal disease has not been observed in Yukon thus far.

The literature specific to Little Brown Bats in boreal regions was limited so we searched for BMPs for insectivorous bats and agriculture. These studies extended to regions other than the boreal forest and to other insectivorous bat species. Despite the diversity of sources, recommendations from various studies converged onto several themes. Thus, it is reasonable that the BMPs for Little Brown Bats on agricultural lands in Yukon include studies from other regions and on other bat species whose life requisites are the same as the Little Brown Bat.

The role of insect-eating bats in agricultural settings has been well documented, with studies in both temperate and tropical climates. Despite differences in climate and agricultural practices, it is widely recognized that bats contribute to crop harvests by controlling insect pests (Landis et al. 2000, Maslo et al 2016). Such pest control amounts to an estimated 3.7 to 53 billion dollars in the United States (Boyles et al. 2011). The control of pests is not limited to consumption of destructive insects. Russo et al. (2018) suggest that bats create soundscapes of fear among tympanate moths capable of hearing bat calls, thereby reducing the damage the moths cause. In a comparison of plots in Illinois, USA, wherein bats (*Lasiurus*, *Nycticeius*, *Myotis* spp.) were and were not excluded, Maine and Boyles (2015) found higher crop damage by corn earworm larvae (*Helicoverpa zea*) and associated fungal infections where bats were excluded. They valued the suppression by bats of damage to corn at 1 billion USD globally. In a similar experiment, Maas et al. (2013) found a 31% decrease of cocoa crop yield in Indonesia with the exclusion of birds and bats (*Hipposideros, Myotis, Megaderma, Rhinolophus*). Bats are also an aid in livestock farming. Ancillotto et al. (2017) found that bats (*Myotis, Pipistrellus, Hypsugo, Eptesicus, Rhinolophus, Nyctalus, Tadarida spp.*) in central Italy preferentially fed above herds of cattle at night, reducing the number of biting mosquitoes (Culicidae) and biting midges (Ceratopogonidae), and therefore reducing potential disease transmission by these insects.

(Top) Little Brown Bats spend daylight hours in roosts where they rest hanging from rough surfaces with their hind legs, in this case inside a human-made roosting box (Maria Leung).

(Bottom) Little Brown Bat in flight (Bat Conservation International).

The most common bat species in Yukon, the Little Brown Bat, consumes 4 to 8 g of insects each night (Anthony and Kunz 1977, Kurta et al. 1989). Those in captivity consume 25% of their body weight per day, a figure that is likely higher in the wild where foraging would be more energetically demanding (Kunz et al. 2011). As with diet studies of Little Brown Bats elsewhere (Fenton and Bell 1979, Nagorsen and Brigham 1993), Talerico (2008) found that Little Brown Bats around Watson Lake in Yukon fed on arthropods (insects and spiders) in proportion to their seasonal availability. Flies (Diptera), moths (Lepidoptera), beetles (Coleoptera), caddisflies (Trichoptera), and spiders (Araneae) were the most common prey in fecal pellets of bats from Watson Lake. Jung et al. (2018) also concluded that Little Brown Bats in Yukon and Alaska had more diverse foraging strategies than the same species living further south It is noteworthy that, unlike data from further south, the studies in Yukon and Alaska suggest that Little Brown Bats engage heavily in gleaning, in addition to typical aerial hawking (Whitaker and Lawhead 1993, Talerico 2008, Shively et al. 2018). Gleaning, where the bat picks prey items directly from vegetation, is used for hunting spiders early in the growing season before flying insects are in sufficient numbers to meet food requirements. Hawking refers to bats catching prey that is flying in the air.

Little Brown Bats begin arriving in Yukon in April and depart by the second week of October when the supply of arthropod food has waned (Talerico 2008, Slough and Jung 2008). Females usually give birth to a single pup sometime between mid-June and late July. Pups are weaned at about 26 days old (COSEWIC 2013). Roosts can be either natural cavities in trees (peeling tree bark or cavities excavated by birds), rock crevices, or spaces in human structures such as attics, under roofs, or in walls of cabins. Human dwellings may be attractive due to the warmth offered by artificial heating (Olson and Flach 2016). Location of roosts is often close to aquatic habitats where prey is most abundant.

Little Brown Bats roost in a variety of natural and human-made structures, often the sheltered ceilings, attics, walls and roofs of buildings. Roosts are often colonial as in this image (Brian Slough).

Studies on bats in agricultural settings have investigated various factors that may influence the health of bat populations, including landscape context of farms, landscape features within farms, use of agrochemicals, role of wetlands, ponds, rivers and other aquatic habitats, crop management, and crop diversity. Although these studies are geographically far ranging (e.g., Eurasia, North America, Africa) they lead to many of the same recommendations. For studies that contrast bats in open habitats (such as pastures) with bats in cluttered habitats (such as interior forests), recommendations for supporting bats that avoid open habitats will be emphasized, because Little Brown Bats in Yukon appear to be anatomically and behaviourally adapted to more cluttered habitats (Talerico 2008).

4.2 Beneficial Management Practices

4.2.1. Landscape Features

- **Maintain well-connected networks of forest so that forest-dependent bats can readily move between feeding and roosting sites.** To enable bats to move from roosts to foraging areas, landscape features with which they can navigate by echolocation and, at the same time, provide cover from predators, are beneficial (Duchamp and Swihart 2008, Park 2014). Connectivity in farmland landscapes is especially useful for shorter-range echolocating bats (such as Little Brown Bats) that use cues at closer distances as these bats are particularly sensitive to habitat fragmentation (Frey-Ehrenbold et al. 2013). Tree groves and scattered trees can act as stepping stones across open areas, connecting foraging areas. The density of patches with woody vegetation is of particular consideration for the Myotis bats. Although these bats tend to shun open areas (Heim et al. 2015), they tend to forage most often along forest edges rather than in the forest interior (Jantzen and Fenton 2013, Thomas and Jung 2019). The presence of linear landscape features composed of trees or hedgerows also promotes movement by Myotis bats (Heim et al. 2015). Bats stayed close to tree and woodland edges while commuting between foraging areas (Downs and Racey 2006). Little Brown Bats forage preferentially along edges of forest stands, with highest levels of activity close to the edge and gradually declining levels of activity for about 40 m both into the forest stand and into the open field (Jantzen and Fenton 2013). They are less active in open areas such as fields and shrublands unless these are associated with water bodies (Coleman et al. 2014). Linear features such as windbreaks and hedgerows support aggregations of insects during high wind velocity, can shelter bats from predators by reducing their visibility to the predator, and can provide acoustic landmarks that help bats to navigate (Boughey et al. 2011, Kahnonitch et al. 2018). Double tree lines, also known as alleys, form an arc-type overstory that is more effective at providing prey and shelter than a single line of trees (Kalda et al. 2015). Suitable habitat along field margins and farm boundaries such as forest edges and riparian strips can support bat populations (Pocock and Jennings 2007, Wolcott and Vulinec 2012, Rodríguez-San Pedro et al. 2018). *In Yukon, little brown bats were much less likely to be active in open areas such as hay fields compared to the edges of water bodies, field edges, and forest interior. They were also less likely to cross open habitats to reach foraging areas around ponds within a few weeks of summer solstice when hours of darkness in Yukon were very few (Slough, Reid, Schultz and Leung, unpublished manuscript).*

Maintaining a network of forest patches and strips in the agricultural landscape, especially connecting water bodies to extensive upland forest, provides necessary movement routes and feeding areas for Little Brown Bats (Donald Reid).

- **Maintain continuous forest along the borders of open fields, rather than just fence rows, to provide suitable foraging and travel habitats along field edges.** Little Brown Bats forage preferentially along edges of forest stands (Grindal and Brigham 1999), with highest levels of activity close to the edge and gradually declining levels of activity for about 40 m both into the forest stand and into the open field (Jantzen and Fenton 2013). Greater forest cover in immediate surroundings of cropland and pasture increases bat activity, and could moderate temperature fluctuations in grasslands, making the agricultural land more agreeable to bats in spring (Heim et al. 2015). Forest dwelling bats such as *Myotis* spp. are negatively affected by forest fragmentation (Henderson and Broders 2008). *In Yukon, Little Brown Bats travelling in upland areas away from water were more active along edges of fields, than in the open fields or the interior of nearby forests. However, their activity along field edges included a relatively low proportion of feeding attempts compared to the forest interior or near water bodies. Limited data indicated that they were rarely active along a fence line with no adjacent trees. These data indicate that the bats often use forested edges of fields for moving between high value foraging and roosting habitats (Slough, Reid, Schultz and Leung, unpublished manuscript).*
- **Maintain a significant proportion of the agricultural landscape as forest in order to retain more bats, and a higher number of bat species.** Little Brown Bats tend to forage more along forest edges (beside waterbodies and clearings such as fields) than in the forest interior or well into the clearings (Grindal et al. 1999, Jantzen and Fenton 2013, Thomas and Jung 2019). Patches of trees support higher abundances of bats than single trees (Kalda et al. 2015). Little Brown Bats are common in landscapes with a higher proportion of forested areas, forest aggregations, and tree corridors (Duchamp and Swihart 2008). Woodlands offer opportunities to forage, roost, and escape predators (Gehrt and Chelsvig 2003). *In Yukon, all the agricultural landscapes that were studied included substantial retention (probably between 20 and 50%) of original forest stands, and each of these landscapes supported a resident group of bats (Slough, Reid, Schultz and*

(Left) Little Brown Bats frequently use the forested edges of fields as movement and feeding corridors (Donald Reid).

(Right) Maintaining a high proportion of the original forest in the agricultural landscape is an excellent way to support Little Brown Bats by providing a mix of commuting and feeding habitats (Maria Leung).

Leung, unpublished manuscript). Further analysis is required to quantify how much of each sampled landscape is comprised of different land cover types (forest, field, water bodies, shrublands, etc.), and relate these patterns to levels of bat activity for a better understanding of how much of the landscape should be kept as forest.

- **Include a mix of types of forest stands in the set of retained forest stands to provide a range of feeding and roosting sites.** Having a mix of vegetation with different heights, sizes and shapes supports greater bat activity (Frey-Ehrenbold et al. 2013). Providing a range of different vegetation heights within forests supports a higher diversity of insects (Duchamp and Swihart 2008) and is positively correlated to bat activity (Kalda et al. 2015). Composition and size of tree patches matters, as does age of trees (Park 2014). Roosting sites tend to be in older trees (Kalda et al. 2015). Managing forests to ensure recruitment of trees suitable for roosting would include retention of large diameter snags and decaying trees that will become snags (Olson and Flach 2016). Hanspach et al. (2012) suggested having a range of tree densities to support different species of bats. Vasko et al. (2020) emphasized the need for mature forests in the boreal zone for *Myotis* and other bat species, as only the larger, older trees can provide roosting sites. Use of forest stands by Little Brown Bats in Yukon decreases as tree density increases (Randall et al. 2011), so forests that are at the pole-sapling stage of succession are likely to be too cluttered for heavy use by these bats. *In Yukon, Little Brown Bats increased their use of interior forest close to summer solstice when daylight was longest. This behaviour allows them to continue to feed in relative darkness at times of the day when there is too much light in more open habitats such as field edges and by waterbodies. The bats' use of forest interiors varied substantially across landscapes, but the proportions of bat calls that included a feeding buzz (11 to 34%) in forest interiors were similar to proportions along edges of water bodies (11 to 39%). This indicates that the interior of forest patches is likely necessary feeding habitat that complements the more commonly used feeding sites near bodies of water (Slough, Reid, Schultz and Leung, unpublished manuscript).*

A mix of deciduous (aspen) and coniferous (spruce) forest patches along with strips of shrubs combine to provide Little Brown Bats with a wider variety of insect prey (Donald Reid).

- **Include a mix of farming practices in space and time on the cleared fields within farms.** Allowing for a variety of habitats over time also supports a greater diversity of arthropods fed on by bats. Methods for achieving this includes crop rotation and allowing portions of land to remain fallow for periods of time (Benton et al. 2003, Ancillotto et al. 2017). *In Yukon, all the open agricultural clearings that were sampled for bats were hayfields, livestock pastures, and occasionally cleared fallow ground. Hay and pasture fields are by far the most common agricultural clearing in south*

Yukon. Only hay fields were sampled when investigating how frequently bats were active and fed well out in clearings. The data showed that bats did occasionally travel across open hay fields (>200 m from forest edge), but fed little in these forays (Slough, Reid, Schultz and Leung, unpublished manuscript).

- **Maintain and/or enhance the structure and functioning of bodies of water in the agricultural landscape.** Bodies of water, such as rivers, lakes, ponds, streams, creeks, and kettle holes, and their adjacent riparian habitats, enhance prey base and foraging opportunities (Wickramasinghe et al. 2003, Kniowski and Gehrt 2014). Landscapes with a mix of terrestrial and aquatic habitats support a larger prey base (Heim et al. 2017). Heim et al. (2017) recommend protecting aquatic habitats on farmland to increase arthropod availability. Wetland habitats and bodies of water support high numbers of insect prey and serve as sources of drinking water where water is limited (Downs and Racey 2006, Korine et al. 2015, Blakey et al. 2017, Heim et al. 2017). Little Brown Bats prefer to forage along riparian edges more than in other habitat settings (Grindal et al. 1999, Coleman et al. 2014). Activity of Little Brown Bats in Yukon is higher closer to water bodies and over riparian habitats than habitats not associated with water (Slough and Jung 2008, Randall et al. 2011, Thomas and Jung 2018). The most straightforward way to maintain Little Brown Bat foraging habitat, as well as many other wetland values, is to keep ponds and small lakes out of agricultural land allocations (and fenced where livestock use adjacent fields). These exclusions would include the water body and an upland buffer above

(Top left) Little Brown Bats feed intensively on the aerial life stages of aquatic insects that congregate along forested shorelines; retention of wide (>40m) buffers of original forest along shorelines is recommended (Maria Leung).

(Top right) Retaining a forested buffer around ponds in fields is highly recommended when ponds lie within farms, because Little Brown Bats prefer to feed along naturally vegetated edges (Maria Leung).

(Left) Bats feed less along the cleared edges of ponds (pasture in foreground) than along forested edges (background) emphasizing the value of retaining original forest beside ponds and small lakes. Bat acoustic recorder installation in foreground (Donald Reid).

the ordinary high water mark. The Forest Resources Regulation regarding riparian retention (Government of Yukon 2011) provides some guidance on buffers, but requires added interpretation. It only addresses lakes larger than 1 ha in surface area, but Little Brown Bats frequently forage over and around smaller water bodies (Thomas and Jung 2018; our observations). It also supports varying width (40 – 100 m) of retention with some forest harvesting allowed. We recommend applying buffers associated with the smallest lake class (1-3 ha) to all small water bodies in agricultural zones, and unharvested buffers of erect woody shrubs and trees at least 40 m wide. We take this width from Jantzen and Fenton (2013) who found that bat activity decreased from a peak along the forest edge to 40 m into the forest. Although this was measured for abrupt edges of upland forest and fields, it provides some direction for the amount of forest to preferentially retain, but also enhance or restore, around wetlands and water bodies. *In Yukon, the edges of ponds, especially those surrounded by mature forest stands, were used by bats more often than other habitats in the agricultural landscapes. Only some field edges had similar levels of activity. The proportion of bat activity that included feeding buzzes was also highest along the edges of ponds. Water bodies and associated riparian forests are key feeding habitats for Little Brown Bats in Yukon. This pattern of heavy use of wetland and pond edges even included some ponds isolated in open fields. However, bat activity in these circumstances decreased around summer solstice and bat activity in nearby interior forests correspondingly increased. This suggested that bats were purposefully seeking darker habitat to avoid flying in open, unforested areas (Slough, Reid, Schultz and Leung, unpublished manuscript).*

4.2.2. Crop Management

- **Avoid the use of pesticides and herbicides wherever possible.** Low pesticide use is associated with higher bat activity (Wickramasinghe et al. 2003, Park 2014, Kahnonitch et al. 2018). "Pesticides" include herbicides, insecticides, and fungicides. Although the reliance of bats on insects can help to control agricultural pests, bats living and feeding in agricultural land are more prone to the effects of pesticides than bats in undeveloped lands where pesticides are not used. Use of agrochemicals on farm fields has been implicated in the reduction of bat populations, either through prey reduction or through biomagnification of toxic substances in the bats themselves. Insecticides reduce insect prey directly whereas herbicides reduce insects indirectly by degrading the habitats on which the insects depend. Little Brown Bats exposed to high concentrations of organochlorine insecticides had stillbirths (Atkar et al. 2009). Bat activity was greater in wheat fields that received lower herbicide and fungicide treatment (Barré et al. 2017).

Organic farms, that avoid use of pesticides and herbicides, are most likely to provide a steady seasonal supply and wide variety of insects for foraging bats (Maria Leung).

- **Include a substantial diversity of farming practices and crops in space and through time across the agricultural landscape.** Higher bat activity is associated with landscapes with more diverse crops and smaller crop fields within the approximate foraging range of individual bats (Monck-Whipp 2018). In the study conducted by Monck-Whipp (2018), the smallest crop fields were <4 ha and the largest fields were >60ha. The number of crop varieties within 50m of sampling sites was correlated to higher biomass of certain insects (e.g., moths) and greater activity of clutter- adapted bats (Olimpi and Philpott 2018). Genetically diverse, traditional varieties of crops support higher diversity of insect prey than the more genetically homogeneous modern varieties of crops with simple crop rotation (Barré et al. 2017).
- **Employ conservation tillage on croplands wherever possible.** Conservation tillage is preferable to conventional tillage if the same amount of herbicide is used (Barré et al. 2017). Conservation tillage in these studies meant that inversion of soil was avoided (i.e. no-till). By contrast, at least 30 cm of soil is turned over during conventional tillage methods. Conservation tillage protects soil integrity, soil microbes, and arthropods in varying stages of development. Such arthropods are potential prey for bats and likely explain the higher amount of bat activity recorded in fields employing this method of tillage (Barré et al 2017).

4.2.3. Livestock Management

- **Limit and control access by livestock to wetlands and to native vegetation stands beside bodies of water and wetlands (i.e. riparian areas), to protect feeding and roosting sites.** Livestock are capable of degrading wetlands and pond edges by removing and trampling vegetation. When this happens along a substantial proportion of the edge of ponds, the ability of the ponds to support the aquatic life stages of insect prey for bats is reduced (Belsky et al. 1999). Control of livestock movements is possible by using fences and by placing mineral sources (e.g. salt blocks) and water troughs away from these sensitive areas (Olson and Flach 2016). Lower grazing intensity can contribute to higher prey base for bats feeding over and near those pastures (Wickramasinghe et al. 2004).

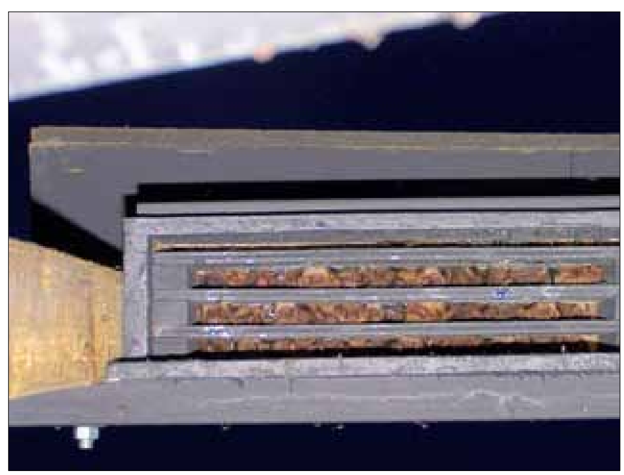
(Left) The ability of small bodies of water to support insect life and therefore food for bats is enhanced when fences keep livestock from disturbing the water and shoreline vegetation (Donald Reid).

(Right) Bats can detect and avoid collisions with wooden fences easier than wire fencing so wooden fencing is preferable close to ponds and wetlands (Donald Reid).

- **Build wooden fences rather than wire fences especially close to ponds and wetlands.** Wooden fences are more easily detected by bats than wire fences. Using the former close to aquatic habitats could reduce risk of collision and entanglement (Olson and Flach 2016).

4.2.4. Farmstead Management

- **Avoid the use of enhanced outdoor lighting during dusk and night around the farm.** Reduction of artificial light at night lowers risk of bats being killed by their predators (Stone et al. 2015, Azam et al. 2016). Insects aggregating close to lights can be an attractant to bats and create a higher risk of predation for the bats themselves (Jones and Rydell 1994, Rydell et al. 1996). Lights can also deter bats from feeding. Talerico (2008) observed a reduction in foraging bouts when ambulance lights were directed at a roost in Watson Lake, Yukon. Vasko et al. (2020) suggested that Myotis are more deterred by artificial lighting than natural light. *In Yukon, where there is limited darkness in summer, bats adapted by increasing their use of the darkest habitats (interiors of forests) for feeding in the weeks before and after summer solstice (Slough, Reid, Schultz and Leung, unpublished manuscript). This habit may reduce the risks associated with artificial light, but strong lights close to roosting sites (such as farm buildings) may still negatively affect their behaviour by making them more vulnerable and by masking the normal light regime.*
- **Provide alternate roosting structures for bats, principally "bat boxes".** Olson and Flach (2016) recommend supporting bats that are already on farmland by giving alternate roosts, especially if the bats are not wanted in the man-made structures that they are occupying (Olson and Flach 2016). Among the many recommendations in The Best Management Practices for Bat Boxes in British Columbia (Community Bat Programs of BC 2019) that are applicable to Yukon, is a recommendation to provide multi-chambered bat boxes as opposed to single-chambered boxes. Uptake of bat boxes by



(Left) Little Brown Bats frequently use bat boxes installed on the sun-exposed sides of farm buildings. Here a white-roofed and a black-roofed box provide Bats with additional choice to avoid risk of overheating in the black-roofed box (Maria Leung).

(Right) Looking up from below a human-constructed bat box reveals Little Brown Bats roosting close together in tight spaces thereby conserving heat (Brian Slough).

bats excluded from their original roosts has been demonstrated for Little Brown Bats (Brittingham and Williams 2000). Before closing-off spaces on buildings that bats use, ensure that the bats have left the area for the winter. Bats are generally absent from Yukon from October through March. Slough and Young (2008) suggested that structures at some farm properties provide roosting sites that are otherwise in short supply in the surrounding area. Installing multiple bat boxes in a variety of settings provides a choice of roosting sites for changing light, weather, risk of overheating, and foraging opportunities over the active season. Community Bat Programs of BC (2019) recommends installation of at least three bat boxes with varying amounts of sun exposure. *In Yukon, 53% of bat boxes placed on farm buildings were used by bats in the initial year of installation, and 76% were used in the subsequent year. The temperature inside some boxes exceeded the tolerable upper limit for Little Brown Bats (42°C) on some days. An experimental use of white roofs on boxes paired with boxes with black roofs showed that such high temperatures could be avoided, though the extra heating provided by fully black boxes is desirable on most days. Having bat boxes of differing roof colours is one way to provide choice of roosting sites that allows bats to avoid risk of overheating (Leung, Reid and Halliday, In press).*

- **Provide a physical structure to help bats escape from human-installed water containers.** Bats feeding over or drinking from water containers are at risk of drowning. Such mortalities have been documented in Yukon (Jung and Slough 2005). Bats have difficulty moving out of water containers with steep sides. Covering such water sources reduces risk (Olson and Flach 2016). Providing escape ramps is another option. This consists of a textured ramp placed at an angle of <45° from the side to the bottom of the water container, allowing the bat to climb out of the water and the container (Taylor and Tuttle 2007). Placing water containers away from obstructions such as barbed wire fences avoids the risk of entanglement by bats flying close to the water containers (Olson and Flach 2016).

5.0. BENEFICIAL MANAGEMENT PRACTICES FOR BUMBLE BEES AND OTHER NATIVE INSECT POLLINATORS

5.1. Background

Four species of bumble bees that occur in Yukon are considered species at risk by COSEWIC. Gypsy Cuckoo Bumble Bee (*Bombus bohemicus*) is considered “Endangered”; Suckley’s Cuckoo Bumble Bee (*Bombus suckleyi*) is considered “threatened”; the Yellow-banded Bumble Bee (*Bombus terricola*) and McKay's Western Bumble Bee (*Bombus mckayi*) are considered “Special Concern”. Critical habitat identified for Gypsy Cuckoo Bumble Bee overlaps farmland in Yukon (Environment and Climate Change Canada 2022). All four bumble bee species have seen declines in abundance and disappearances at various locations in Canadian provinces where they were previously found. Threats include pathogen spillover both from managed bumble bees used in greenhouses and from honey bees (*Apis mellifera*), pesticides, habitat loss, and competition for food from honey bees (COSEWIC 2014a, 2014b, 2015, 2019). Managed bumble bees are wild species that have been captured and propagated, mainly for use in greenhouses. The origins of these managed species are both European and North American (Winter et al. 2006, Goulson and Hughes 2015).

(Top left) A Bumble Bee approaches haskap flowers to feed on nectar and pollen (Maria Leung).

(Top right) A McKay's Western Bumble Bee, one of the four species of Bumble Bee at risk in Yukon (Maria Leung).

(Left) The Endangered Gypsy Cuckoo Bumble Bee is found in the agricultural landscape of southern Yukon (Syd Cannings)

The literature review for bumble bees was not specific to just the species at risk in Yukon, but was for bumble bees in general and for other native insect pollinators (e.g., other native bee species, wasps, syrphid flies, moths, butterflies, beetles). The contribution to pollination of agricultural crops by native pollinators has been, and continues to be, a very active field of study. Many different researchers working in temperate regions have made recommendations on how to protect this ecosystem service, and the BMPs are based on their insights

The four bumble bee species-at-risk have all been recorded in Yukon within the last five years and recent surveys have contributed to an understanding of their distribution (Environment Canada unpublished data). McKay's Western Bumble Bee is the most common and widespread in Yukon, found throughout the Boreal Cordillera ecozone. Gypsy Cuckoo Bumble Bee overlaps the distribution of McKay's Western Bumble Bee but is less common. The Yellow Banded Bumble Bee has only been found in southeast Yukon. It is difficult to characterize the distribution of Suckley's Cuckoo Bumble Bee in Yukon, as records are few and widespread, ranging from the southwest to north into the Taiga Cordillera Ecoregion. Both the Gypsy Cuckoo Bumble Bee and Suckley's Cuckoo Bumble Bee are social parasites and depend on the presence of their host species, which include Western Bumble Bee and Yellow-banded Bumble Bee, for provisioning their offspring (COSEWIC 2014b, 2019).

Bumble bees are among the many insects in Yukon that pollinate native plants. By visiting multiple flowers to gather nectar and pollen, the bumble bees move pollen from anthers to stigma, allowing the plants to form seed and reproduce. Native insects, such as bumble bees, can also be valuable pollinators of agricultural crops (Kremen et al. 2002). In Yukon, this includes berries, squash, beans and herbs. It is well known that pollinators are essential for many food crops, and also contribute significantly to the productivity of crops that are not solely dependent on animal pollinators (Klein et al. 2006). In Yukon, most of this service is provided by insects, including a wide variety of bees, flies, moths, butterflies, and beetles. Bees are especially effective at pollination due to their need to gather pollen to feed their offspring (Winfree 2010). Bumble bees are particularly well-suited for northern crops because of their ability to be active in cool temperatures, their wide breadth of floral choices including non-native plants, and the relatively long duration of their active season (Heinrich 2004, Leung and Forrest 2019, Weissman et al. 2021). Most other bee species (e.g., mining bees, leafcutter bees) in Yukon have shorter active seasons, and therefore a more restricted set of flowers on which to feed.

In landscapes more heavily altered by humans, where pollinator habitats are heavily degraded, researchers are devising methods to restore habitats that will provide native pollinators with nesting and foraging opportunities, including the use of native forbs (Dumroese et al. 2016, Drobney et al. 2021). In Yukon, where wildlands are still being actively converted to agricultural clearings, there is the opportunity to focus efforts on retaining suitable nesting and foraging habitats in conjunction with agricultural clearings, in addition to restoring such habitats in some circumstances.

A variety of insects pollinate crops, in addition to bumble bees: mason bee (top left) and marsh fly (top right) feeding on strawberry flowers; mining bee (bottom left) and longhorn beetle (bottom right) feeding on raspberry flowers (Maria Leung).

The widespread misperception that raising honey bees contributes to the conservation of native pollinators and is essential to the pollination of native plants is pervasive in North America and in Yukon (Colla and MacIvor 2017). Honey bees are not a native species in North America and are not the primary pollinators of native plants. However, honey bees can contribute significantly to pollination in intensive agricultural systems (Colla and MacIvor 2017), particularly in large areas of single crops such as huge expanses of canola fields and almond orchards (Glenny et al. 2017). These landscapes, with limited wildlands and high use of pesticides and herbicides, often have a lower diversity of insects including fewer native pollinators (Cane and Tepedino 2001, Raven and Wagner 2021). However, in less altered landscapes such as Yukon, the contribution of native pollinators to crop success can still function as it did in the era before intensive agriculture. During this era, when the sizes of farms were smaller and wildlands adjacent to farms were commonplace, population

Honey bee feeding on yellow lucerne (Maria Leung).

levels of native pollinators were usually adequate for pollinating crops, and the value and revenue generated by raising honey bees was primarily from honey, not from pollination services (Belfrage et al. 2005, Rucker and Thurman 2019).

There are many risks to native pollinators associated with introduced bees, including competition for floral resources, disruption of plant-pollinator interactions, and spread of pathogens (Goulson 2003, Thomson 2016, Magrach et al. 2017, Henry and Rodet 2018, Renner et al. 2021). Because honey bees recruit their nest mates to floral sources, they are able to monopolize food sources to the detriment of native bees, none of which recruit conspecifics to food sources (Hung et al. 2019, Valido et al. 2019). Pathogen and parasite spillover from honey bees to bumble bees include *Nosema ceranae* (a microsporidian), Israeli Acute Paralysis Virus, Deformed Wing Virus, Sac Brood Virus, Black Queen Cell Virus, and Small Hive Beetle (Singh et al. 2010 in Goulson 2015, Goulson 2015, Colla 2016). Managed bumble bees risk infecting native bumble bees with *Nosema bombi*, implicated in the decline of several bumble bee species (COSEWIC 2014a, 2015). The most common exotic bee in Yukon is the honey bee. Non-native bumble bees have also been used in greenhouses in Yukon, and there are a few instances where non-native mason bees (*Osmia* sp.) have also been imported.

Guidelines for beneficial practices for pollinators have been written for several jurisdictions, for example, Canada (Woodcook 2012), United States (Vaughan et al. 2015), and Britain (Department of Environment, Food and Rural Affairs 2014). These include many resources for persons interesting in learning more, but they were primarily written for landscapes situated in warmer climates where only a small proportion of the land base remains as intact forest, wetlands or other wildlands. In our set of BMPs, we have included and adapted the most relevant guidelines from these resources and written additional recommendations specific to the Yukon context.

5.2. Beneficial Management Practices

5.2.1. Landscape Features

- **Retain parcels of forested lands for nesting, overwintering and feeding within and adjacent to farms.** Bumble bees require small cavities to nest in, such as old rodent burrows. Queen bumble bees require protected sites below ground to survive the winter. Sources of pollen, including tree pollens, and nectar from the forest are of particular value early and late in the growing season, when queen bumble bees first establish their colonies, and when agricultural crops have finished flowering (Colla 2016, Mola et al. 2021). Openings in forest with abundant and diverse herbaceous plant cover are generally favourable for bees and butterflies (Hanula et al. 2016).
- **Retain areas that are naturally rich in nectar and pollen food.** Areas naturally rich in nectar and pollen include field and forest edges, and riparian habitats (Schweitzer et al. 2012, Colla 2016). Evans et al. (2018) found that wild bee abundance and diversity were higher in landscapes that enhanced or retained grasslands, wooded areas, and wetlands. Martínez-Núñez et al. (2022) found that semi-natural herbaceous habitat in the agricultural landscape supports a greater number of pollinator species than mass-flowering crops. They attributed this pattern to the higher diversity of forage plants for pollinators, both spatially and temporally, in semi-natural habitat.

(Top left) Forest edges and patches beside and within fields provide necessary nesting sites for native pollinators including Bumble Bees (Donald Reid).

(Top right) A hedgerow of willows provides a valuable mix of early season feeding plus nesting sites for Bumble Bees that feed on the adjacent haskap crop (Maria Leung).

(Left) Native pollinators require strips of unmowed meadow and hedgerows supporting a variety of flowering plants during the growing season (Maria Leung).

- **Establish windbreaks that incorporate nesting and foraging opportunities.** When planning to clear land, strips of forest can be left to act as windbreaks. For existing cleared land, windbreaks of trees, shrubs and flowers can be planted. Lowering the wind speed can increase the foraging efficiency of bumble bees (Mola et al. 2021). Willows are a favoured spring food of many pollinators including bumble bees though pollen from other trees may also be harvested (Vaughan et al. 2015, Mola et al. 2021). Such tree species can be incorporated into windbreaks.
- **Keep foraging habitat close to nesting habitat to minimize energy for travel.** Use of floral resources by most native bees begins to drop off beyond 100 m of their nest sites, although bumble bees will forage further afield if necessary (Woodcock 2010, Schweitzer et al. 2012). Nesting habitat that is close to or within fields would reduce travel time of pollinators to flowers.


(Left) Strips of mature trees intersecting fields break the wind making it easier for Bumble Bees to feed. They also provide nest sites for the pollinators and act as snow fences thereby retaining moisture on fields in spring (Maria Leung)

(Right) Willow flowers are a high value source of nectar and pollen for Bumble Bees in spring (Maria Leung)..


(Left) Nesting habitat in forest close to feeding areas of berry crops flowering at different times enhances the ability of a variety of native pollinators to occupy the area (Maria Leung).

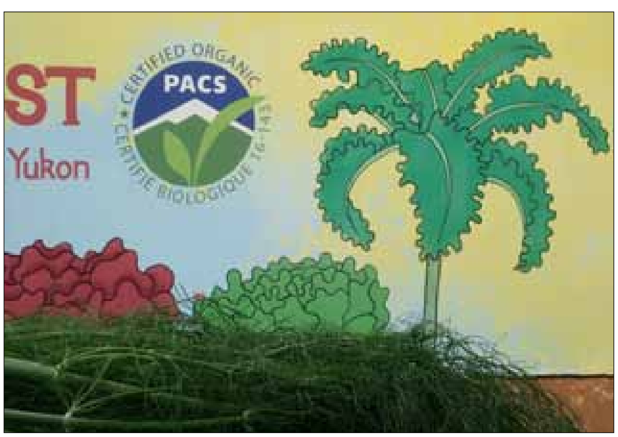
(Right) A copse of trees and a hedgerow of willows both provide excellent nest sites and alternative feeding areas for Bumble Bees who pollinate the flowers of haskap berry bushes (rows in foreground) (Maria Leung).

- **Incorporate feeding habitat for pollinators alongside existing features such as field edges and roadsides, ensuring that there is enough variety of flowering plants to span the growing season.** Bumble bees have a long active season and require flowers for pollen and nectar for most of the growing season (May to August). Encourage growth and proliferation of existing native flowers as these will be pre-adapted to the site.

Unmanaged meadows within the farms, often as strips beside fields and roads, can provide flowers in bloom over the course of the growing season (Donald Reid).

5.2.2. Crop Management

- **Avoid the use of pesticides, herbicides, and fungicides wherever possible.** Neonicotinoids and Diflubenzuron are known to be toxic to bees, whereas *Bacillus thuringiensis* (Bt) is not known to affect bees (Schweitzer et al. 2012). Bt is routinely applied in Yukon, especially in municipalities, to control mosquito populations (Duka Environmental Services, unpublished data). Though a wide variety of other pesticides are sold and applied in Yukon, information on the extent and frequency of use is unavailable. Bumble bees exposed to herbicidal formulas with surfactants, sold under the trademarked name "Roundup", exhibited 30% to 94% mortality (Straw et al. 2021). Elston et al. (2013) found sublethal effects on bumble bees exposed to the fungicide propiconazole.
- **Control pests through cultural and mechanical methods in lieu of pesticides.** Cultural methods are based on making the habitat less acceptable to pests. A method that is commonly used is rotating vulnerable crops with crops that the pest of concern will not affect. This crop rotation keeps the population of the pest at low levels (Hill 1989). Mechanical methods are based on physically excluding pest species from vulnerable crops. An example is the use of row covers during the period when pest species are most likely to affect the crop (Dara 2019).



(Left) The Certified Organic label ensures that the produce being sold is grown without herbicides, pesticides and fungicides. These agrochemicals pose a risk to pollinator health (Maria Leung).

(Right) The use of row covers over young vegetables can protect plants from frost and from damage by some insect pests (Maria Leung).

- **If pesticides are necessary, target specific pests and minimize damage to beneficial insects.** Targeting specific pests is a contrast to prophylactic use of systemic pesticides such as canola seed pre-treated with neonicotinoids (Colla 2016). Examples of the targeted approach are minimizing use of pesticides while forage plants are in flower, and reducing risk of pesticides drifting onto foraging and nesting habitats of bees by applying pesticides only on calm days.
- **Plant crops that provide feeding opportunities to bumble bees and other pollinators.** All varieties of berries grown in Yukon provide potential pollinator food, including haskap, gooseberry, currant, raspberry, and strawberry. Many herbaceous crops are also suitable, including chives, onions, sage, lavender, and borage. Yukon cover crops used by pollinators include alfalfa, clover, and field peas. Planting a variety of crops that will flower in succession across the farm landscape provides a sustained set of food sources throughout the bees' active season.

(Top left) A crop of field peas provides feeding opportunities for Bumble Bees (Maria Leung).

(Top right) Haskap berries result from early season pollination of flowers mainly by Bumble Bees who tolerate colder temperatures (Maria Leung).

(Left) Raspberries result from mid-season pollination of flowers by a diversity of native pollinators (Maria Leung).

- **Time activities to minimize damage to bee nests and feeding opportunities.** To avoid activity that interferes with nesting and foraging bees, schedule treatments, such as tilling and burning in fields, to early or late in the growing season before colonies establish or after colonies have produced queens for the following year. Schedule mowing of crops such as clover in fields for after their flowers senesce (Schweitzer et al. 2012).

- **Intercrop perennial crops for human consumption with food plants for bumble bees and other pollinators.** For domestic crops such as berries that require pollination, intercropping with other flowering plants will increase the stability of pollinator populations in the same field (Chan 2012). Evans et al. (2018) found that there was a perceptible benefit to bees with as little as 1% of the area supporting flowers used by bees among crops not fed on by bees. A Yukon example of intercropping is to have native plants such as wild strawberry, goldenrod, fireweed, kinnickinnick, scorpion weed, groundsel, northern bluebells, lupine, and penstemon growing in-between rows of haskap bushes. These native flower species can be alternative food sources after the haskap bushes have finished blooming.

Bumble Bees and other pollinators can better persist among berry crops when other flowering plants are grown in the same field. Here, rows of black currant and haskap bushes that flower early in the season are intercropped with mid-season flowering strawberries (white flowers) (Maria Leung).

5.2.3. Livestock Management

- **Control access by livestock to habitats of high value to bees in agricultural land holdings.** To sustain forage opportunities for bumble bees, control access by livestock to riparian, wetland, and forested habitats to prevent grazing and trampling of vegetation during the growing season. This can be done by barriers such as fencing, or timing livestock access to outside the growing season to minimize damage to pollinator habitats.

Fencing is required to protect flowering plants in wetland borders and meadow strips from trampling and feeding by livestock (Donald Reid).

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- **Limit and control access by honey bees to habitats outside of agricultural lands.** In Yukon, movement of all domestic livestock is controlled, except the honey bee. Yet, the honey bee poses the same risk to native species as other livestock pose, including pathogen spillover and competition for food. Currently, Yukon does not have a set of territory-wide regulations explicitly for managing honey bees, nor does it have a registry of apiaries. These are gaps that need to be filled. Other Canadian jurisdictions have legislated restrictions on movement of honey bee hives, including Ontario (Bee Act), Nova Scotia (Bee Industry Act), and British Columbia (Animal Health Act). Restricting movement is intended to reduce the risk of introducing pathogens from honey bees at one location to another location. This has the added benefit of reducing pathogen spillover to native bees. Hatfield et al. (2018) recommend placement of honey bee apiaries greater than 4 miles (6.4 km) from known locations of native pollinators at-risk, wilderness areas, and habitats of special value for pollinators or other biodiversity. Limiting the size and spacing of apiaries would reduce competition with native pollinators and among honey bee colonies (Hatfield et al. 2018).

Honey bees are raised in portable hives in various settings in Yukon. Improved management could reduce risk of food competition with native pollinators and of spreading pathogens to native bees (Maria Leung).

- **Ensure adequate management of honey bee apiaries in Yukon in order to minimize risk to native bees.** Yukon does not have a formal set of territory-wide regulations to govern management of honey bees. Yukon needs to draft, formalize, implement, and enforce beekeeping regulations. Confirm that beekeepers are invested in keeping their honey bees healthy and treating infections that may spill over to wild populations of native bees. To reduce risk of pathogen spillover to bumble bees from honey bees, ensure that honey bees that will be brought into Yukon are parasite free, given sterile food and housing, and screened for disease before and after arriving (Goulson 2015) at destinations in Yukon.
- **Prohibit the importation to Yukon of managed bumble bees.** Managed bumble bees that have been imported are known to spread pathogens to native bumble bees and have been implicated in the decline of several species, including species that are still found in Yukon (COSEWIC 2014a, 2014b, 2015; Environment and Climate Change Canada 2022). Newfoundland is proactive in minimizing the risk of disease spillover from managed bumble bees by prohibiting the import of commercially produced bumble bees under Section 83 of their Wild Life Regulations.

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