UNIVERSITY OF VICTORIA - ER390

Bird-assisted Restoration Using Snags at Grand Manan Island Migratory Bird Sanctuary

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ABSTRACT

The Nature Conservancy of Canada (NCC) is starting a multi-phase restoration project on their Grand Manan Island, New Brunswick conservation property. This report describes a component of the restoration which aims to expedite succession through avian seed vectors, by erecting snags on the site that will serve as bird perches and wildlife trees. NCC site restoration goals include improving ecological value of the degraded former homestead, farm, and gravel quarry; this bird-snag component aims to connect restoration efforts to the site's status as a Migratory Bird Sanctuary and Important Bird Area. The site is part of the Fundy Coastal Ecodistrict within the Atlantic Martitime Ecozone. Through previous site inventory, ecosystems surrounding the gravel quarry were classified as Alder Thicket, Lowland Barrens, and Wet Coniferous forest. Barren, soil-stripped portions of the site would have supported coastal spruce-fir (*Picea-Abies*) forests. Field work took place between September 2022 and March 2024 and included spatial/gap assessment to inform snag placement, site vegetation and bird surveys, snag installation, and monitoring set-up through baseline inventory. Within the old gravel quarry, vegetation structure was found to range from Sparse-cryptogam to Shrub/Herb; tiny tamarack (*Larix laricina*), balsam fir (*Abies balsamea*), and spruce (*Picea sp*) trees are scattered in with shrubs like white meadowsweet (*Spiraea alba*) and herbaceous grasses and goldenrod (*Solidago sp*); terrain texture within the quarry comprises angular shale, rubble, and gravel and lacks soil structure. Six whole trees (two balsam fir, two tamarack, and two spruce) were transported to the site and planted with the help of machinery in open areas of the quarry; these are meant to decay and effectively serve as wildlife tree snags. Measuring from 7.2-9.1 metres tall, the snags are beacon-like within the area. Fifty-six bird species were observed at the conservation property during field work surveys; of those, at least 27 species were observed within or near the edges of the quarry, and 3 species were observed landing on the snags after installation, including Northern Flicker (*Colaptes auratus*). Citizen science data (eBird) has recorded a total of 184 species visiting the site (year-round, all years). In order to boost the probability that birds' seed rain might help plant vegetation under that snags, Coarse Woody Debris was scattered underneath, and forest topsoil was spread around three of the snags. Long-term monitoring will include photopoint monitoring, vegetation surveys in 5-metre radius circle plots around each snag, and bird surveys. Adaptive management recommendations include options for adding more CWD around the snags, and planting shrub islands, specifically native berry-producing shrubs that could attract more birds.

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1.0 INTRODUCTION

Habitat loss, habitat degradation, and habitat fragmentation are major factors in the loss of biodiversity and bird populations globally (Guo et al. 2023; Rosenberg et al. 2019). Migratory bird populations risk finding damaged habitats ranging across their breeding grounds, migration stopovers, and wintering locales. Rosenberg et al. (2019) established that since 1970 in North America, nearly three billion birds have been lost, with one billion birds vanishing from forest ecosystems. Nocturnal migratory birds across the eastern portion of the continent have reduced drastically since 2007, as evidence from weather radar shows (Rosenberg et al. 2019; Guo et al. 2023). Also reflecting steep bird declines, data from Canadian bird populations document that 44 forest bird species are decreasing, and 13 aerial insectivore species have diminished since the 1980s (NABCIC 2019). Improvements in the quantity and quality of bird habitats can positively impact birds' fitness and therefore reproductive success (Deppe & Rotenberry 2008). Conserving Canadian forests, which sustain birds' migrating, feeding, roosting, and breeding grounds, will support aerial insectivores and forest birds alike (NABCIC 2019).

The Acadian Forest in New Brunswick has a deep history of logging and forest management, which, in part, eliminates old growth and replaces forests with tree plantations; this diminution of forest ecosystem biodiversity has led to the significant decline of forest bird species and populations in the region (Betts et al. 2022). A report of trends in biodiversity in the Canadian Atlantic Maritime Ecozone, of which New Brunswick is a part, concurs, noting that forest bird populations are shrinking in the region, especially since 2000 (ESTR 2014). Correlated with bird reductions, only 1-5% of regional forests are older than 100 years. Largely originally clearcut for agriculture and logging, the younger forests now exhibit simplification in species and ecosystem diversity (ESTR 2014). Forest restoration efforts have demonstrated the ability for humans to help reverse declines in woodland bird communities (Belder et al. 2018); improved forest structure and increased forest area drive forest bird population recovery (Bennett et al. 2022; Hamel 2003).

The Nature Conservancy of Canada (NCC) owns a conservation property on Grand Manan Island in New Brunswick which lies within a federally-designated Migratory Bird Sanctuary (MBS 2022; NCC 2024). This designation alone does not indicate overarching habitat quality within the sanctuary; in fact, a portion of the property is heavily degraded from its history of agricultural use and gravel extraction (ACFOR 2023; Dowding 2023; personal observation). Barren ground, roads, and all-terrain vehicle (ATV) trails punctuate the landscape that was once forested. Tasked with its mission to conserve important natural areas and biodiversity across Canada (NCC 2023), NCC is undertaking a site restoration.

This paper details a design component of the restoration that focuses on bird activity. Considering Grand Manan's position along the Atlantic Flyway, a major corridor for bird migration, and the Grand Manan Archipelago's designation as an Important Bird Area, with globally significant concentrations of migratory landbirds (IBA n.d.), restoration of this fragmented forest has the potential to positively impact Grand Manan bird populations and contribute to national and global bird population recovery targets (CNF 2002). In compliment to NCC's overarching goal to return ecological integrity to the damaged areas, this component seeks to speed succession of the site by

drawing birds, known to disperse seeds through excrement, to perching snags in the barren areas (see Table 1. Goals and Objectives); over time, site bird activity and communities will change in relation to the site's vegetation recovery through successional stages.

1.1 Site Description

Location

Grand Manan Island lies at the entrance of the Bay of Fundy, known for some of the largest tides in the world, off the coast of New Brunswick at its junction with Maine. The island is 24 km long and 10 km in greatest width (Heald 2015). The 158 hectare NCC conservation property known as Henderson's Point is situated along the southeast coast of the island at Ox Head; the property neighbours Anchorage Provincial Park and comprises forest, wetland and coastal ecosystems (MBS 2022). Ox Head Road provides access into the peninsular property, and multiple ATV trails and rogue tracks cut through shrubby meadows leading towards the coast. NCC's restoration area encompasses about 21 ha, while this paper's topic—the bird-focused restoration component—concentrates on work within an approximately 2.3 ha patch (Figure 1).

Figure 1 - Location of Henderson's Point restoration site, 44.65685, -66.77166. Left: Yellow outline indicates the approximate area of the bird-focused component within the NCC property; Top right: Grand Manan's position in the Bay of Fundy; Bottom right: Context view of the site along Grand Manan's southeast coast. Red stars are the restoration site location. Maps adapted from EODMS (2024) and Google Earth (2024)

Ecological Context

New Brunswick follows an Ecological Landscape Classification (ELC) system (Zelazny 2007). According to the ELC, the broad region is known as the Atlantic Maritime Ecozone—also referred to as Acadian Forest—the transition between temperate broad-leaved forest and northern Boreal forests. Forests display a mix of tree species, often including birch (*Betula* spp.) and maple (*Acer* spp.), as well as spruce (*Picea* spp.), balsam fir (*Abies balsamea*), and tamarack (*Larix laricina*). The site is further classified into the Fundy Coast Ecoregion and Fundy Coastal Ecodistrict. Cold water in the Bay of Fundy influences climate, moderating winter and summer temperatures compared with greater extremes in continental New Brunswick. Grand Manan coastal areas are often enshrouded by fog, and the cool marine air yields a primarily coniferous forest along the coast (Maine DACF 2021). According to ELC coarse filter surveys, the Ecosite classification for NCC's property is Ecosite 2—approximately 50% red and white spruce; 20% intolerant and tolerant hardwood species; 15% balsam fir; and a mixture of other species in smaller numbers—while a small portion of the property is Ecosite 3o—comprising over 60% spruce species (ACFOR 2023). Neighbouring Maine calls corresponding coastal forests stretching to the New Brunswick border Maritime Spruce Fir Forest (Maine DACF 2021), characterized by spruce, balsam fir, and tamarack, with birch and mountain-ash (*Sorbus americana*) possible.

The St. Croix Highlands Geomorphologic Region encompasses Grand Manan Island (Fahmy et al. 2010), and Henderson's Point falls within the Ingalls Head Formation (Fyffe & Grant 2005). Felsic volcanic rock, high in silica, underlies the site, whereas most of Grand Manan Island comprises low silica mafic volcanic bedrock (ACFOR 2023). Soils in this region are shallow, acidic, and mesic, with sandy-loamy texture, lying over bedrock and till (Davis 1966; Maine DACF 2021). The soils have been classified as Lomond gravelly loam, considered shallow and stony (Wicklund & Langmaid 1953).

NCC staff conducted a baseline inventory on the property in 2017 using the Atlantic Canada Ecosystem Classification Keys (NCC 2021). Ecological communities were classified, in part, as Quarry (Cultural Land - CL8); Alder Thicket (Inland Wetlands - IW14); Lowland Barrens (Inland Uplands - IU6); Black Spruce / Cinnamon Fern / Sphagnum (Wet Coniferous Forest - WC1); and Balsam Fir / Cinnamon Fern - Three seeded Sedge / Sphagnum (Wet Coniferous Forest - WC6). ACFOR (2023) reports 1.5 ha of shale and 3.8 ha of non woody vegetation within the NCC restoration focus area; these fall within the classified CL8 Quarry community. Succession along forest edges into the quarry is slowly occurring, with alder, tamarack, balsam fir, and spruce the predominant tree species, often displaying a lack of vigour (personal observation). Areas of open shale and lichen-encrusted ground are interspersed with shrubs and grassy herbal regrowth, including white meadowsweet (*Spiraea alba*) and goldenrod (*Solidago*). The quarry is surrounded by fairly intact mixed spruce-balsam fir forest, shrubby meadows dotted with white spruce, and pockets of wet alder (*Alnus*) communities. Canopy height models show that forest trees reach between 8-12 metres (ACFOR 2023). The site is about nine metres in elevation and modestly sloped towards the water. Drainage is mixed throughout the site. The larger NCC property and Migratory Bird Sanctuary landscape includes ponds, bogs, and coastal ecosystems, and a few rural residential houses lie along Ox Head Road leading into the site.

1.2 History

Prior to European settlement of Grand Manan Island in the late 1700s (Heald 2015), the Passamaquoddy traditionally hunted porpoise and seal, collected berries and gathered sweet grass on the island; tools and spears 4,000 years old have been found on Grand Manan beaches (Grand Manan Museum n.d.). Since European arrival, New Brunswick has relied on more intensive resource use: Charlotte County, which includes Grand Manan, "led the logging sector at the very beginning" (PANB 2024). In a 1945 survey of the vascular plants of Grand Manan, Weatherby & Adams (1945) describe the continued modification of the forests: "the vegetational aspect of the main island has changed notably even since…1926, almost wholly as the result of lumbering." The Henderson family, after whom NCC's property is affectionately called even today by locals, was already homesteading at Ox Head by 1900 (Grand Manan Museum n.d.). The land was eventually abandoned as farmland; subsequently, a gravel quarry existed through the early 2000s (ACFOR 2023). It is unknown exactly how long the quarry operated, but its area is estimated to have been about 18.5 ha (Patrick & Murtagh 2017); one can surmise that the most heavily quarried land included areas that remain bare shale, visible from current satellite images as a scar on the landscape (Figure 2, right), even as the former agricultural land (Figure 2, left) has partially recovered. Recently, in addition to hikers and dog-walkers, the site has drawn ATV riders, who cut through meadows towards the coast, perpetuating habitat damage, and people using the site as a partying and dumping ground (Dowding, personal communication 2023; personal observation).

Figure 2 - Left: 1945 air photo of Henderson's Point, showing the extent of agricultural land use; Right: Current satellite image showing bare ground (shale) following quarrying. Sources: Historical photo courtesy of NCC; Google Earth (n.d.)

Impressions of bird life on Grand Manan paint a favourable picture of bird activity and diversity. During a bird survey trip to the island, naturalist Olin Sewall Pettingill (1936) says that "from the very outset of my visit I could not fail to be impressed with the great abundance of certain species of land birds." Pettingill was especially dazzled by the presence of wood warbler species, flycatchers, and both chickadee species nesting. By the time of his visit in

1936, the Grand Manan Migratory Bird Sanctuary had already existed for 5 years (MBS 2022), although historically, migratory sanctuaries were created to protect birds from disturbance and hunting without consideration for habitat protection (CNF 2002), thus the Henderson property, within the sanctuary, would not have been subject to land use regulations stemming from the MBS designation. Even today, lack of management plans for many MBAs mean that private landowners have no culpability for damaging habitat (CNF 2002). NCC acquired the property around 2017 and, as a conservation organization, is taking on the onus of repairing the land damage. Figure 3 shows the context of the MBS area and the greater NCC property. Grand Manan continues today to be an impressive and popular birding destination: Grand Manan Tourism and Chamber of Commerce highlights birding as a major activity, and their website describes the best birding spots on the island and includes a birds checklist (GMTACC n.d.). About 360 bird species have been recorded in recent years, 130 of which breed on the island. Several eBird "hotspots", noted birding areas for citizen science observations (Sullivan et al. 2009), exist on the island, including one on the NCC MBS property.

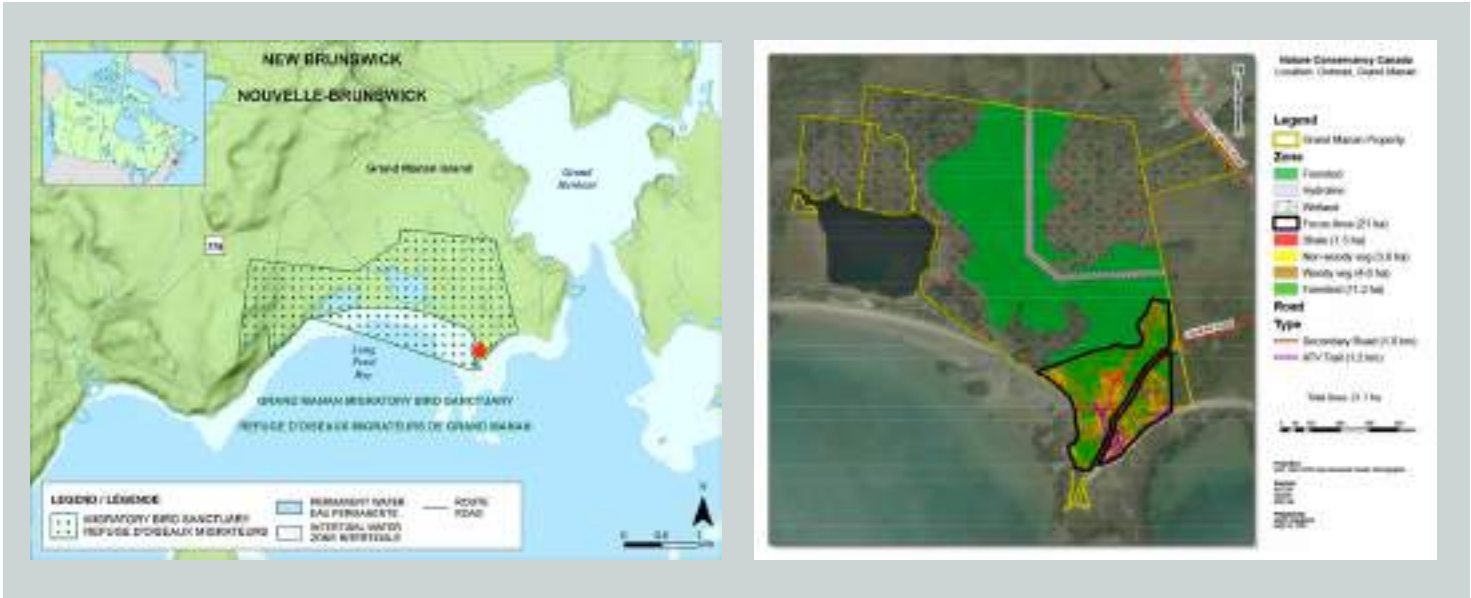

Figure 3 - Left: Grand Manan Migratory Bird Sanctuary, with the restoration site at Henderson's Point starred in red; Right: NCC MBS property, outlined in yellow, with their 21 ha restoration focus area outlined in black and shale patches marked in red. Sources: MBS (2022); ACFOR (2023)

1.3 Project Design

Approach

NCC aims to improve ecological value of the site through their own restoration design. Site work for NCC Phase 1 of a multi-year restoration plan runs simultaneous to this bird-focused component. In part, NCC's Phase 1 promotes responsible access and use by visitors while excluding activities that promote anthropogenic damage to the site—chiefly ATV riding and garbage dumping. Boulder blocking of certain paths will channel visitors down

main trails and exclude off-trail use. Additionally, Phase 1 involves re-contouring, pit-and-mound operations, and a tree-planting effort partly within the degraded quarry area (Dowding 2023), with work overlapping the bird-focused project area. As the highly disturbed site will benefit from a multi-faceted restoration approach, the bird-centred component is designed to take place alongside these changes and to complement and enhance NCC's restoration goals. Figure 4 shows the site before any restoration work.

Figure 4 - Drone image from 2022 of the degraded former quarry, where NCC and this project's restoration efforts will focus. NCC will additionally restore rogue ATV tracks cutting down towards the south (bottom right corner of the image). Image courtesy of NCC/Riley Chevrier

The idea of the bird-focused restoration component is that snags are erected in areas where little vegetation has regrown; birds drawn to land on the snags will be employed as vectors for reintroducing vegetation to the site that was once forested. In concept, the snags will facilitate a restoration for the birds by the birds: birds should land on the snags and produce excrement containing seeds primed for germination (seed rain), returning nutrients to the barren ground and stimulating ecological succession over time. Erected snags will be left to follow the natural course of decomposition, eventually providing cavities for nesting birds and wildlife. As the snags fall—likely a decade or decades in the future—biomass will be added into the system as Coarse Woody Debris (CWD), engaging fungi and soil organisms (Figure 5).

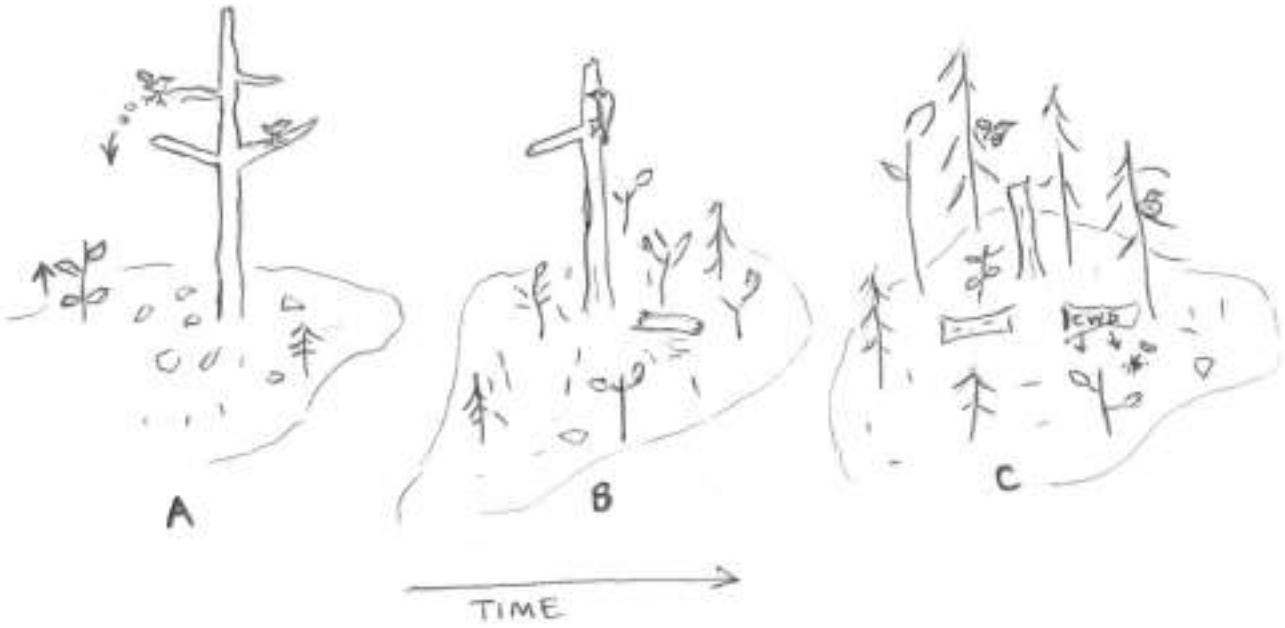

Figure 5 - Depiction of bird snag restoration concept: in A, birds land on snag branches and deposit seed rain on the barren ground below, propagating new vegetation; in B, the snag is partially decomposed, with vegetation continuing to fill in underneath and the snag serving wildlife; in C, the CWD from the decomposing snag adds nutrients into the ground, promoting soil health, while vegetation grows taller and enters new structural stage. As the site recovers, different groups of birds will find use of varied vegetation architecture. Drawing by the author

Background

This portion of the restoration accounts for the difficulty of traditional planting and seeding on highly disturbed substrate, instead opting to trigger regeneration using birds' seed inputs to fill in vegetation gaps. A lack of places for birds to land in the open could also indicate limited pathways for seed arrival. Polster (2009) suggests that on drastically disturbed sites, restoration should apply natural processes to foster recovery, and that creating conditions for plant colonization may "require providing perching locations for birds as they pass through the disturbed area." Many studies agree birds play a large role in seed dispersal and suggest that perches can draw them to disturbed, open areas (Robinson & Handel 1993). Forest structural components play a role in seedling success by attracting avian dispersers to degraded sites: dead trees used as perches increase seed rain, seedling survival, and plant diversity compared to when trees are removed (Genes & Dirzo 2022). In this way, snags help maintain continuous and diverse bird-dispersed seed inputs, which could accelerate ecological succession (McClanahan & Wolfe 1993). In a review of literature examining birds and restoration outcomes, birds were found mainly to have positive restoration impacts due to their role as seed dispersers, as well as from increased nitrogen input to the soil from their excrement (Ortega-Álvarez & Lindig-Cisneros 2012).

Beyond potentially triggering succession and accelerating the return of forest, snags are also in and of themselves an important forest structural element. Within a bird sanctuary, adding components that will quickly attract and

benefit birds is a desired target in addition to vegetative restoration. Forestry guides recognize the importance of maintaining standing dead trees in forests as well as in clearcuts for the benefit of birds (Fyles & Kopra 2005). In a study of clearcut forest plots, areas with snag retention showed greater bird species richness, abundance, and diversity; species using snags for foraging and perching were more abundant, and cavity-nesting birds occurred on snag plots but were absent from snagless clearcuts (Dickson et al. 1983). Snags are often a crucial habitat component not only for cavity nesting, but also for singing and foraging. For example, the Olive-sided Flycatcher, a federally designated Species at Risk (Threatened), forages and gives vocalizations from the top of upright dead snags, and snag availability is closely associated with appropriate habitat for Olive-sided Flycatcher (Environment Canada 2016). Forest management guidelines in New Brunswick for the Greater Fundy Ecosystem recommend managing snags on a landscape level but note that even single snags are useful: snags left in clearcuts are used by bird species that feed in the open, including Northern Flicker, Tree Swallow (*Tachycineta bicolor*), and American Kestrel (*Falco sparverius*) (Betts & Forbes 2005). Left to decay, snags become habitat for insects, small mammals and other creatures; CWD eventually cycles carbon and nutrients into the system (Moroni & Harris 2010).

The Bay of Fundy acts to funnel migrating birds, and this site provides a first point of contact with land for fatigued birds. It also contains ecosystems that support a variety of breeding birds during the summer. The more functional and continuous the dynamic forest ecosystem becomes over time, the better the habitat will be able to provide for forest birds' needs (George & Zack 2001).

Goals and Objectives

Table 1. Project goals and objectives

Goal #1: Speed ecological succession of the site by making it more attractive to avian seed dispersers, while contributing wildlife value to the landscape
Objectives
Erect perching snags to fill spatial gaps using locally-sourced native trees; allow snags to naturally decompose and become wildlife trees
Create list of bird-attracting native vegetation that could be planted around snags
Goal #2: Track success of snags, measuring changes to both vegetation and bird activity
Objectives
Conduct baseline plant surveys around snags and measure snags for wildlife attributes
Observe bird species and behaviour on snags following installation
Recommend possible additions of CWD or soil to area around snags in case seedlings resulting from bird droppings fail to thrive in poor substrate
Set up photopoint monitoring plots around snag locations to track changes into the future
Recommend bird behaviour observation protocol for snags

Goal #3: Increase knowledge of bird use and visits to the site/Migratory Bird Sanctuary
Objectives
Conduct bird counts during all site work
Recommend data sources for analysis, including NCC site monitoring, Breeding Bird Atlas surveys, and eBird citizen science data
Recommend bird monitoring protocols to track changes in bird use of the site over time

2.0 METHODS

Field visits and work for this bird-focused restoration component were conducted between September 2022 and March 2024. Monitoring will commence in the Spring of 2024. Along with my own field observations, NCC staff and a consultant from ACFOR, a forestry company focused on sustainability in the Acadian Forest, conducted site visits and work. Community members with years of bird observation experience participated in bird counts.

2.1 Project Planning

Aerial photos and satellite images were used to delineate ecosystem boundaries. ACOFR prepared canopy height maps to visualize site vegetation structure, and soil models from Geo NB (2022) for the site were consulted. Groundtruthing with handheld GPS confirmed boundaries of ecological and zones and determined where the most degraded areas were. Snag project design was discussed with NCC staff and ACFOR to determine feasibility of snag installation and to coordinate site goals to complement the NCC restoration. Areas with the least amount of vegetation regrowth were targeted, including open shale and sections of shallow soil with limited herb-shrub regrowth, as in Figure 6. A rough spatial analysis determined several locations where snags might be placed in the open, away from forest edges. A combination of spatial and budget considerations (funding from NCC) determined that it would be possible to install 4-6 snags.

Figure 6 - View of shallow soil and shale at the site. Photo by the author

2.2 Snag Installation

Six snags were installed on September 7, 2023 (Figure 7). Tree species were selected on the basis of local suitability, availability, and decomposition rate—species that decay more slowly were desired to facilitate snag longevity. Trees were harvested from a local Grand Manan wooded property slated to be cleared for a rifle range. Live trees were used because they were easier to obtain than already-cut logs. From an ecological standpoint, obtaining trees that would have been cut down regardless was essential, and ultimately it was decided that creating snags from live trees would better fulfill project goals: namely, the branches of live trees are intact and can provide more perching area; and installing live trees will theoretically allow for a longer period of time that they stand and serve as perches before fully decaying. ACFOR and NCC facilitated communication with the contractor and machine operator to guide tree selection. A large excavator removed the trees from the ground, rootballs intact; the trees were transported to the site by truck. For maximum efficiency and minimal duration of noise and disturbance, NCC incorporated the snag installation into their wider site plan (Phase 1) that also used the excavator to create pits and mounds within the gravel quarry. An excavator dug holes for the snags, aiming for a depth of 70-100 cm or more where possible. Precise snag placement was driven in part by the ability of the excavator to dig deep enough to place the snag in the ground. A crane and guidelines lifted and guided snags into place; once the snag was upright, the hole was backfilled around the root ball and trunk and tamped with the excavator bucket. Some trees were packed with additional shale and substrate around the trunk, mounding soil and rock up to one metre aboveground to for added stability. It was discussed whether the trees might in fact survive the transplanting, but significant bark scarring from truck transport and the machine grapples is akin to girdling. To compare future seeding success surrounding snags, screened, intact forest topsoil from the rifle range was spread several centimetres deep around three of the six snags. CWD was placed around the base of some of the snags along with branches that were stripped from the trees to make them more beacon-like to birds.

Figure 7 - Heavy machinery was used for snag installation, including a truck to transport trees to the site, an excavator to dig holes in the rocky substrate, and a crane to lift the trees into the holes. Photos by Aaron Dowding

Snag Safety

Table 2. Snag safety considerations

Safety Concern	Action
Safety during installation	Installation followed NCC and contractor safety protocols.
Tree stability	The ideal depth to bury trees was loosely guided by wood power pole recommendations to bury 10% of the length plus 60 cm (Lovelace 2017). Where full depth was not achieved, rocks and soil were packed up around the base of the tree for support.
Public safety	Snags were purposely arranged on site so they are not directly adjacent to pathways and roads.
Decay	Snags are meant to follow the natural course of decay. Monitoring will determine the decay trajectory of the snags over time and whether adaptations need to be made to the structures to retain site safety. Angers et al. (2012) have shown that snags can lose half their initial density and still remain upright.

Snag and Ground Condition Measurements

Table 3. Methods for measuring baseline conditions following installation

Purpose	Methods and Tools
Measure trees installed as snags, take initial photos, describe condition, and indicate wildlife tree attributes	GPS waypoints were taken at each snag to map their locations; photos were taken with a digital camera for photopoints, and the photopoint coordinates were recorded. Diameter at Breast Height (DBH) of each snag was calculated using tape measured circumference divided by pi (π). Tree height was estimated averaging results from two methods: [1] using tangent triangle calculations with known (measured) observer distance (d) to the tree and compass angle (A) to the tree top, then solving for h (tree height) + observer eye height; and [2] marking a visible point on the tree with masking tape (152 cm, approx. 5 ft. up), and standing a distance away from the tree with tape measure to create a scale from the ground to the known tape-height, then measuring the full height of the tree with tape measure from that same observation distance and solving for the actual tree height using the scale. Tree condition parameters and features supporting wildlife were observed and described, guided by the "Tree Attributes for Wildlife" section of the BC *Field Manual for Describing Terrestrial Ecosystems* (2010).
Conduct a baseline inventory of vegetation cover and ground conditions around the installed snags	Five metre radius circle plots were measured around snags; plot size should capture the potential seed rain area, beyond branch reach. Within each circle, ground conditions, moisture and soil were described; vegetation species were identified and % vegetation cover by layer (tree, shrub, herb, moss) was recorded using visual estimate. Unknown vegetation was identified using field guides *Trees & Shrubs of the Maritimes* (Boland 2012), *Wildflowers of New Brunswick* (Boland 2015), and iNaturalist (n.d.).

2.3 Bird Surveys

Several types of surveys were conducted to gain an understanding of birds currently using the site. Methods described here relate only to bird surveys completed by the author and NCC staff during project planning and site work. Note that eBird citizen science data are suggested to draw upon for future site monitoring (see Discussion section).

General Bird Counts

For each visit, I counted all birds seen or heard using binoculars and a field notebook to record observations. Birds were identified by my own knowledge from several years of experience and at-home study of calls, songs, and field marks. These general efforts did not follow a standardized census protocol: each route varied, and surveys fell within different time periods; additionally, the amount of attention towards specifically observing birds fluctuated throughout each visit (i.e. sometimes birds were noted incidentally while I was measuring vegetation). Consistent parameters between all general counts included not using playback; counting individual birds only once; and noting all bird species and number of individuals seen or heard, regardless of perceived distance away or their activity at the site (flying overhead vs. foraging in the trees). I entered my data into eBird, using the site hotspot location (https://ebird.org/hotspot/L6140961). This type of survey indicates bird presence and contributes to the general NCC property bird species list.

Bird-Snag Observations

After trees were installed, I observed birds that landed directly on the snags, noting bird species and behaviour (singing, feeding, perching, etc). These observations will provide information about which species have used the perches, and through behaviour observations may give clues about the wildlife value the snags provide.

Point Counts

NCC established a point count protocol for the restoration site and conducted several counts May through August, 2023 (Patrick 2023). Counts closely follow other protocols established by Birds Canada for various terrestrial point count monitoring programs (Birds Canada 2024) and Canadian provincial Breeding Bird Survey programs. The NCC site point count protocol is to observe at four predetermined locations spread 200 metres apart (minimum) for 10 minutes each; birds are recorded within an unlimited distance, and counts are to be conducted between one half hour after sunrise and five hours after sunrise. During breeding season, 2-6 counts should occur with six days minimum between counts. To ensure consistent data collection, observers for point counts should have confidence identifying local species by sight and sound; this improves the ability to replicate sampling (Bibby et al. 1998) in future surveys. Figure 8 shows the point count locations within the site. Note that Point 3 is within the quarry and installed snags area.

Figure 8 - NCC Grand Manan MBS point count map. Source: Patrick (2023)/NCC

2.4 Site Vegetation Surveys

NCC conducted ecosystem classification on the site in 2017. The purpose of additional surveys for this project was to confirm ecosystem boundaries, identify vegetation, and qualify the successional stage of communities surrounding the gravel quarry.

Table 4. Vegetation survey methods

Purpose	Methods and Tools
Groundtruthing: Describe ecosystems and vegetation associations	I walked through the site with satellite maps, recording vegetation transitions and marking points of interest with handheld GPS. Habitat, topography, and dominant vegetation in the forest and fields surrounding and within the quarry were described. Unknown plants were identified in the field using Boland field guides *Trees & Shrubs of the Maritimes* (2012) and *Wildflowers of New Brunswick* (2015) and off-site from photographs using iNaturalist (n.d.).
Describe succession and structural stage	I observed plant communities, noting factors controlling succession, including habitat condition, soil type, aspect, disturbance, slope, and seedling recruitment. The *Field Manual for Describing Terrestrial Ecosystems* (2010) "Structural Stage" section guided observations. Several trees were cored during groundtruthing with an increment borer to understanding tree ages around the site. Soil hand-texturing was performed where possible, guided by the *Field Manual* (2010) "Soil texture key".

3.0 RESULTS

3.1 Snag Descriptions

Snag Locations

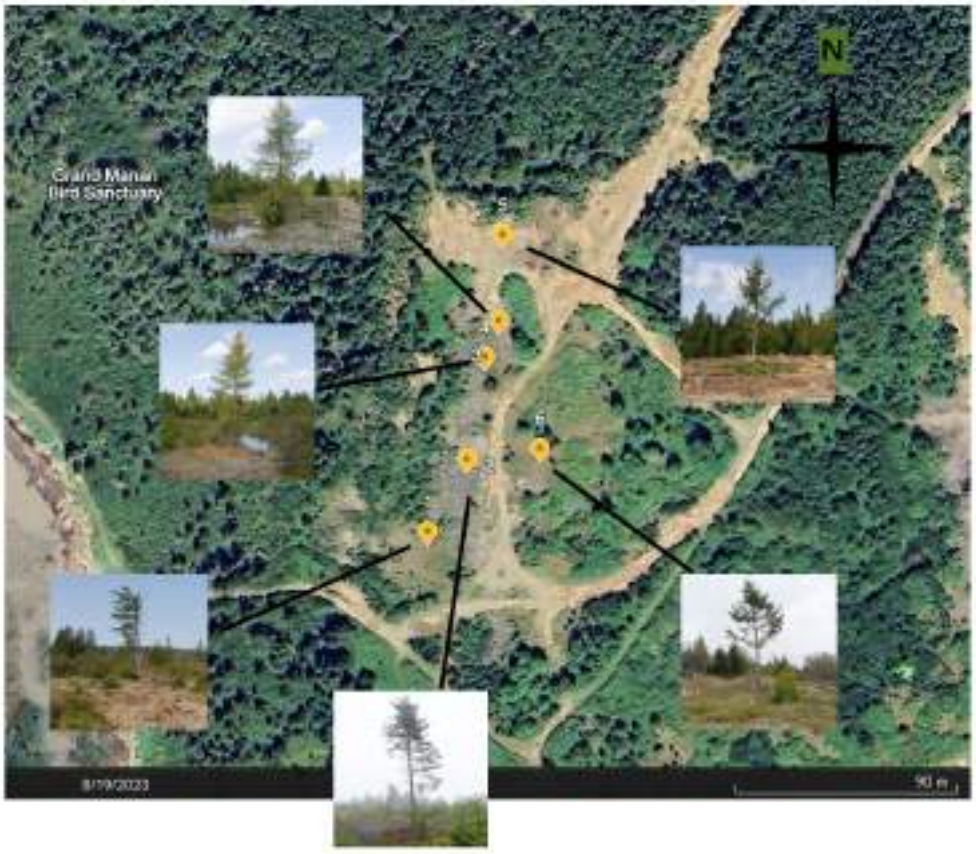

Figure 9 (right) - Map of snag locations (numbered 1-6) and initial images of each tree. Coordinates:
Snag 1 N 44.65633°, W 66.77202°
Snag 2 N 44.65659°, W 66.77182°
Snag 3 N 44.65696°, W 66.77173°
Snag 4 N 44.65709°, W 66.77166°
Snag 5 N 44.65740°, W 66.77164°
Snag 6 N 44.65663°, W 66.77145°
Map adapted from Google Earth, n.d. Photos of each snag by the author

Snag Measurements

Wildlife codes based on the "Tree Attributes for Wildlife" sheet from the *Field Manual for Describing Terrestrial Ecosystems* (2010) are given in the chart below (Appearance, Crown condition, Bark retention, Wood condition, and Wildlife use activity); full key can be found in Appendix C. As a breeding season has not occurred since the time of snag installation and the writing of this report, certain indications of wildlife use have not been observed. Future monitoring can include indices for the Wildlife use category (see Monitoring).

Table 5. Tree Attributes for Wildlife of Snags 1-6

	Species	Height (m)	DBH (cm)	Appear-ance	Crown Condition	Bark Retention	Wood Condition	Wildlife Use
1	BF - Balsam Fir (*Abies balsamea*)	7.2	18	2	2	2	1	-
2	BF - Balsam Fir (*Abies balsamea*)	9.1	19	2	2	2	1	-
3	TL - Tamarack (*Larix laricina*)	7.2	13	2	2	2	1	-
4	TL - Tamarack (*Larix laricina*)	7.8	11	2	2	2	1	-
5	WS - White Spruce (*Picea glauca*)	6.3	15	2	2	2	1	-
6	WS - White Spruce (*Picea glauca*)	7.8	21	2	2	2	1	-

Comment: Appearance and crown condition were manufactured by removing some branches and topping some snags; bark damage occurred during transit and installation. Note that trees are not meant to survive transplanting, but are intended to start decaying.

Code key: (from *Field Manual* (2010)) Appearance: Code 2 = Unhealthy; internal decay or growth deformity; broken tops; dying tree /Crown condition: Code 2 = Some or all foliage lost; possibly some twigs lost; all branches usually present; possible broken top / Bark retention: Code 2 = Bark lost on damaged areas only (<5% lost) / Wood condition (texture/soundness classification): Code 1 = No decay / Wildlife use: none observed

3.2 Snag Vegetation Plots

Initial surveys of ground conditions and vegetation present within five metre radius circle plots, snag at the centre, were conducted on October 18th and October 25th, 2023. Slope is near zero, thus plots have an indeterminable aspect. None of the plots has vegetation taller than waist height; therefore, all tree species present are listed in the shrub layer (B).

Snag 1

Snag has cobble mounded around the base for support; branches/CWD are scattered around but do not cover the ground. Position of plot is flat to slight depression; a few small puddles fill the bottom of pits created from NCC pit-and-mounding, although drainage is mixed, with some well-drained spots. Substrate is a mixture with gravel and heavy shale; the disturbed soil has no discernible layers, nor is it possible to manually dig deeper than a few cm. Hand-textured soil exhibits a slightly sticky (10-25% clay), grainy (50-80% sand) quality.

Figure 10 - Ground conditions around Snag 1

Vegetation % Cover By Layer

A (tree) 0%	B (shrub) <1%	C (herb) <5%	D (moss) <1%
	Picea glauca - White spruce	*Solidago* sp. - Goldenrod	*Bryophyta* - Mosses
	Larix laricina - Tamarack	*Trifolium* sp. - Clover	
	Ribes hirtellum - Smooth gooseberry	*Vicia* sp. - Vetch	
	Dasiphora fruticosa - Shrubby cinquefoil	*Poaceae* - Grasses	
	Spiraea alba - White meadowsweet		

Snag 2

Forest topsoil was added around base of the snag, radiating approximately 2 metres out from the trunk and several centimetres deep; a few branches/CWD are scattered around the plot. This snag plot is in a slight depression. Terrain is almost exclusively shale; manual digging was not possible. Note: Snag 2 exhibited a slight lean shortly after installation, but has since been righted.

Figure 11 - Ground conditions around Snag 2

Vegetation % Cover By Layer (Snag 2)

A (tree) 0%	B (shrub) 3%	C (herb) <1%	D (moss) <1%
	Picea glauca - White spruce	*Echium vulgare* - Viper's bugloss	*Bryophyta* - Mosses
	Larix laricina - Tamarack	*Poaceae* - Grasses	
	Betula sp. - Birch		
	Abies balsamea - Balsam fir		
	Spiraea alba - White meadowsweet		

Snag 3

Forest topsoil was added around base of the snag; it radiates approximately 2 metres out from the trunk and is several centimetres deep; a few branches/CWD are scattered around the plot. There is a small, shallow pool between Snag 3 and Snag 4. Where there is standing water, drainage appears to be poor; some spots are moderately well-drained. Terrain is almost exclusively shale; in certain areas, pockets between the angular blocks are filled with soil, mosses and vegetation.

Figure 12 - Ground conditions around Snag 3

Vegetation % Cover By Layer

A (tree) 0%	B (shrub) 3%	C (herb) 4%	D (moss) <1%
	Picea glauca - White spruce	*Echium vulgare* - Viper's bugloss	*Bryophyta* - Mosses
	Larix laricina - Tamarack	*Poaceae* - Grasses	*Polytrichum* sp. - Haircap moss
	Betula sp - Birch	*Solidago* sp. - Goldenrod	
	Abies balsamea - Balsam fir	*Trifolium* sp. - Clover	
	Spiraea alba - White meadowsweet	*Fragaria virginiana* - Virginia strawberry	
	Dasiphora fruticosa - Shrubby cinquefoil	*Rubus* sp. - Brambles	

Snag 4

No soil or rock piled around the base; a few branches/ CWD scattered. There is a small, shallow pool between Snag 4 and Snag 3. Where there is standing water, drainage appears to be poor; some spots are moderately well-drained. Heavy shale throughout the plot; a few pockets between the angular blocks are filled with soil, mosses and vegetation.

Figure 13 - Ground conditions around Snag 4

Vegetation % Cover By Layer

A (tree) 0%	B (shrub) 4%	C (herb) 1%	D (moss) <1%
	Picea glauca - White spruce	*Poaceae* - Grasses	*Polytrichum* sp. - Haircap mosses
	Larix laricina - Tamarack	*Vicia* sp. - Vetch	*Ptychostomum pseudotriquetrum* - Long-leaved thread moss
	Alnus alnobetula - Green alder	*Trifolium pratense* - Red clover	*Stereocaulon* sp. - Foam lichens
	Abies balsamea - Balsam fir	*Pilosella officinarum* - Mouse-eared hawkweed	
	Dasiphora fruticosa - Shrubby cinquefoil		

Snag 5

Plot is in area with NCC-created pit-and-mound contours, scattered hay; a few planted saplings (*Alnus* or *Betula*) are just within the plot. Topsoil was added around the base of the snag, with scattered CWD and branches. Terrain contains cobble and boulders (up to soccer ball size), mixed with gravel and soil, especially where the machine turned up the ground. Drainage is moderately well drained. A nearby soil profile (turned up by the machine) did not reveal discernible horizons, but allowed for hand-texturing: reddish soil is sticky and grainy.

Figure 14 - Ground conditions around Snag 5

Vegetation % Cover By Layer (Snag 5)

A (tree) 0%	B (shrub) 0%	C (herb) <1%	D (moss) <1%
		Poaceae - Grasses	*Bryophyta* - Mosses

Snag 6

CWD/branches scattered. Ground is a mix of soil and shale. This plot contains a significantly higher percentage of vegetation cover than other plots; ground is slightly spongy, with thick grass and moss. There is a small mound on the north side of the plot. Soil is disturbed with a mixture of gravel; texture is sticky and grainy.

Figure 15 - Ground conditions around Snag 6

Vegetation % Cover By Layer

A (tree) 0%	B (shrub) 2%	C (herb) 50%	D (moss) 5%
	Picea glauca - White spruce	*Echium vulgare* - Viper's bugloss	*Bryophyta* - Mosses
	Larix laricina - Tamarack	*Poaceae* - Grasses	*Polytrichum* sp. - Haircap moss
	Abies balsamea - Balsam fir	*Solidago* sp. - Goldenrod	
	Spiraea alba - White meadowsweet	*Trifolium* sp. - Clover	
	Dasiphora fruticosa - Shrubby cinquefoil	*Vicia* sp. - Vetch	
	Vaccinium angustifolium - Lowbush blueberry	*Equisetaceae* sp. - Horsetail	

3.3 Bird Data

General Bird Counts

Table 6. Fifty-six bird species were observed throughout the NCC site during field work for this project and are listed in the table. *Starred species were observed within the gravel quarry or along its edges.

Canada Goose	*Branta canadensis*	*Philadelphia Vireo	*Vireo philadelphicus*
Mallard	*Anas platyrhynchos*	*Blue Jay	*Cyanocitta cristata*
American Black Duck	*Anas rubripes*	*American Crow	*Corvus brachyrhynchos*
Common Eider	*Somateria mollissima*	Common Raven	*Corvus corax*
Surf Scoter	*Melanitta perspicillata*	*Black-capped Chickadee	*Poecile atricapillus*
Bufflehead	*Bucephala albeola*	Barn Swallow	*Hirundo rustica*
*Ring-necked Pheasant	*Phasianus colchicus*	*Ruby-crowned Kinglet	*Regulus calendula*
Ruffed/Spruce Grouse	*Tetraonini*	*Golden-crowned Kinglet	*Regulus satrapa*
*Mourning Dove	*Zenaida macroura*	*Red-breasted Nuthatch	*Sitta canadensis*
Black-bellied Plover	*Pluvialis squatarola*	Winter Wren	*Troglodytes hiemalis*
Semipalmated Plover	*Charadrius semipalmatus*	*Gray Catbird	*Dumetella carolinensis*
Spotted Sandpiper	*Actitis macularius*	Hermit Thrush	*Catharus guttatus*
Sanderling	*Calidris alba*	*American Robin	*Turdus migratorius*
Least Sandpiper	*Calidris minutilla*	Cedar Waxwing	*Bombycilla cedrorum*
Semipalmated Sandpiper	*Calidris pusilla*	American Pipit	*Anthus rubescens*
Herring Gull	*Larus argentatus*	*Purple Finch	*Haemorhous purpureus*
Great Black-backed Gull	*Larus marinus*	*American Goldfinch	*Spinus tristis*
Common Loon	*Gavia immer*	American Tree Sparrow	*Spizelloides arborea*
Double-crested Cormorant	*Phalacrocorax auritus*	*Dark-eyed Junco	*Junco hyemalis*
Great Blue Heron	*Ardea herodias*	*White-throated Sparrow	*Zonotrichia albicollis*
Northern Harrier	*Circus cyaneus*	*Savannah Sparrow	*Passerculus sandwichensis*
Bald Eagle	*Haliaeetus leucocephalus*	*Song Sparrow	*Melospiza melodia*
Belted Kingfisher	*Megaceryle alcyon*	*Common Yellowthroat	*Geothlypis trichas*
*Downy Woodpecker	*Picoides pubescens*	*American Redstart	*Setophaga ruticilla*
Hairy Woodpecker	*Leuconotopicus villosus*	*Yellow Warbler	*Setophaga petechia*
*Northern Flicker	*Colaptes auratus*	*Palm Warbler	*Setophaga palmarum*
*Alder Flycatcher	*Empidonax alnorum*	*Yellow-rumped Warbler	*Setophaga coronata*
*Least Flycatcher	*Empidonax minimus*	*Black-throated Green Warbler	*Setophaga virens*

Bird-Snag Observations

Figure 16 - Yellow-rumped Warbler (*Setophaga coronata*) (left) and Common Yellowthroat (*Geothlypis trichas*) (right) along the forest edges of the gravel quarry before snag installation. Photos by the author

Casual observations of birds interacting with the snags since the time of installation are listed below:

- 2023/Sept/11 - Palm Warbler; landed on Snag #1
- 2023/Sept/21 - Northern Flicker; flew between Snag #3 and Snag #4, landed on both
- 2023/Sept/21 - Yellow-rumped Warbler; fed on Snag #2

Point Counts

Table 7. Nineteen bird species were recorded at point count Point 3 (within the gravel quarry) over eight surveys performed by NCC staff and local birders between May-August 2023 prior to snag installation.

Canada Goose	*Branta canadensis*	Gray Catbird	*Dumetella carolinensis*
Ring-necked Pheasant	*Phasianus colchicus*	American Robin	*Turdus migratorius*
Herring Gull	*Larus argentatus*	Savannah Sparrow	*Passerculus sandwichensis*
(Gull sp.)	-	Song Sparrow	*Melospiza melodia*
Common Loon	*Gavia immer*	Red-winged Blackbird	*Agelaius phoeniceus*
Alder Flycatcher	*Empidonax alnorum*	Northern Waterthrush	*Parkesia noveboracensis*
Blue-headed Vireo	*Vireo solitarius*	Black-and-White Warbler	*Mniotilta varia*
Red-eyed Vireo	*Vireo olivaceus*	Common Yellowthroat	*Geothlypis trichas*
American Crow	*Corvus brachyrhynchos*	American Redstart	*Setophaga ruticilla*
Common Raven	*Corvus corax*	Northern Parula	*Setophaga americana*

3.4 Site Vegetation and Ecosystems

Figure 18 shows approximate zones containing similar vegetation and structure. A more complete list of vegetation observed around the site is given in Appendix B. See Appendix C for structural stage descriptions.

Descriptions below relate to Figure 18:

- Black line - gravel access road through site.
- A - Forest (in green on the map): Mixed forest characterized by spruce (mostly white, some red) and balsam fir with some birch; mountain ash also occurs; forest is damp; canopy closure 60-80%. Soil pit (30 cm deep) shows top 5 cm humus, 5-10 cm down clay, then pea-sized gravel, greasy soil and angular coarse pieces. Structural stage appears to be mostly Mature Forest with some gaps, and Young Forest along the edges.

Figure 18 - Vegetation/structural stage zones. Adapted from Google Earth (n.d.)

- B - Regeneration (in red on the map): Mixed shrubs, grasses, and saplings characterized by regenerating tamarack, spruce, fir, and alder with meadowsweet and goldenrod. Soil is highly disturbed or completely stripped; shale and gravel substrate underlie new vegetation. Structural stage is a combination of Gramminoid-dominated Herb and Shrub/Herb.
- C - Gravel quarry (in purple on the map): Bare ground, rock, and shale, some encrusted by lichens. Sparse vegetation growing between rocks or in cracks in the ground. Structural stage is Sparse/cryptogam, with less than 10% vegetation cover.
- D - Meadow (in blue on the map): Dense shrubs characterized by shrubby cinquefoil, meadowsweet and bracken fern (*Pteridium aquilinum*) with occasional tall white spruce trees (core sample taken shows approximate age of larger spruce 85 years), and some herbacious cover including goldenrod. Structural stage is Tall shrub; succession may be inhibited by the density of cover.
- E - Wet alder (in yellow on the map): Transition area includes introduced plants and trees (willow (*Salix*), snowberry (*Symphoricarpos albus*)); wet area of dense alders stretches further southeast. Structural stage is Tall shrub, with scattered mature trees.
- F - Grassy (in grey on the map) Lumpy, disturbed ground with grasses and other herbaceous vegetation growing; willow trees, shrubs, and damp areas with moss growth. Soil is disturbed and gravelly. Structural stage is Shrub/Herb.

4.0 DISCUSSION

The erection of snags within the degraded gravel quarry on Grand Manan has the potential to help bird populations in various points of their life cycles. Birds that favour open areas for feeding, calling, and resting can immediately make use of the site; as the site recovers through successional stages, different bird species may find new suitable forage, cover, and breeding spots. Over time, as the forest matures, a more intact and resilient ecosystem may draw an assemblage of forest breeding birds and support the needs of migratory and overwintering species, thus contributing to bird conservation within this Migratory Bird Sanctuary. As birds are ecological indicators (Maritimes BBA; Ortega-Álvarez & Lindig-Cisneros 2012), the continued study of birds on the site may contribute to understanding the effects of restoration (Gregory et al. 2004).

The snags themselves have already withstood several storms, including Hurricane Lee, which hit New Brunswick in September, 2023 shortly after the snags were erected. A powerful storm in December 2023 also hit Grand Manan especially hard, with wind speeds around 85 km/hr according to weather data. Grand Manan's exposed position in the Bay of Fundy means that the site will see many storms to come; these early tests show that the snag installation was well-executed.

While the snags may see some wildlife use over the course of their decay, their small DBH will exclude potential nesting use by larger cavity-nesting species; for example, the minimum DBH for Black-backed Woodpecker (*Picoides arcticus*) nesting trees is 31 cm, and for Pileated Woodpecker (*Dryocopus pileatus*) is 51 cm (Fyles & Kopra 2005). This project, however, does not target specific species of birds, and Athiê & Dias (2016) point out that in the beginning stages of restoration, generalist birds that tolerate disturbed landscapes will be the early visitors to open perches thus crucial for early forest succession.

Through monitoring and tracking changes in snag use, site vegetation, and bird occurrence, it may be possible to make assertions regarding the success of the snags. However, new vegetation growth might not be visible for several years, and it will be impossible to determine if seedlings are a result of bird-introduced seed or other allochthonous input. Another challenge is that the measurement of bird population trends tends to be a decades-long endeavour, so changes in bird use of the site overall may not necessarily be attributed to snags, other than direct snag use observations.

When monitoring changes in vegetation around the snags, it might become clear that the presence of added soil is crucial to hosting seedlings from bird excrement. Martínez-López et al. (2019) note that a possible limiting factor for seedling establishment is rocky substrate. Because the Grand Manan quarry lacks soil with intact layers and structure—indeed, beneath several installed snags lies bare shale—the area around snags without added soil might fail to support vegetation growth. Additions of soil, CWD, or shrubs around the snags could enhance restoration outcomes: shrub islands may facilitate seedling establishment (Holl et al. 2000) and could draw more birds, especially if the shrubs are berry-producing.

A strength of this particular study is that the site belongs to a dedicated conservation organization committed to continued restoration and stewardship. NCC Phase 2 of restoration will begin in 2029 and include further ground decompaction and planting of early successional hardwood tree species (Dowding 2023). General site monitoring typically occurs each summer by conservation staff; some observations and simple monitoring related to this snag project can easily be performed during this general monitoring. More time-intensive monitoring tasks are scheduled every few years (see Monitoring below). Additionally, with eBird soaring in popularity, and Grand Manan drawing tourists and birders every year, there will be citizen engagement and bird counting data for years to come.

4.1 Monitoring

Snag Monitoring

As the standing dead trees decay, they may acquire features that become valuable to wildlife. Snag monitoring will contribute to knowledge of how snags benefit wildlife on the site; additionally, monitoring will illuminate any human safety issues that may arise.

Table 8. Snag monitoring scheme

Type of monitoring	When / Who	Methods
Safety	Casually, during general site monitoring / Site stewards or NCC staff	Site stewards and NCC staff can be alert to obvious safety hazards posed by snags (for example, if a branch is poised to fall near a pathway). NCC staff/professionals should address issues (e.g. cut off the branch) and leave any felled wood in its location on site.
Tree Attributes for Wildlife (TAW)	Suggested every 2 years (2025, 2027, 2029…) during general site monitoring / NCC staff	During NCC staff site monitoring, notes should be made following the Tree Attributes for Wildlife table; see Appendix C for field manual sheets (Tree Attributes for Wildlife) and Appendix D for suggested monitoring form.
Bird-snag interactions	Casually, any time & recommended more formally every 2 years as part of TAW monitoring (see point above) / Site stewards or NCC staff	Any time NCC staff or site steward knowledgeable about birds sees bird activity on the snags, they should record which snag (if known), the bird species, and its behaviour on the snag: for example, was it scanning from a high perch for insects? Feeding off the bark? Singing or calling? Interacting with other birds? Did it fly away or excrete? Formally, bird-snag interactions should be recorded along with TAW measures (see Appendix D for suggested monitoring form).

Vegetation Plot Surveys and Photopoint Monitoring

Plot surveys and photopoint monitoring will show how vegetation is growing up around snags over time. Analysis of vegetation growth patterns may also help show whether birds specifically contributed to “planting” vegetation: for example, if plants are concentrated close to the snag but are absent or thinner farther away from the base, it might support the idea that seed rain is responsible for the growth. Monitoring vegetation around the snags will also determine whether adaptations need to be made to restoration plans going forward: for example, if the three

snags with added soil around the base support far more growth than those without added soil, NCC will have more information to support decisions about whether to bring in soil for the remaining snags or other locations on the site (see Recommendations).

Table 9. Vegetation plot surveys and photopoint monitoring scheme

Type of monitoring	When / Who	Methods
Plot surveys	During summer (or late spring/ early fall), when vegetation is growing; Suggested every 5 years (starting 2029, or as convenient in preparation for NCC Phase 2 planning) / NCC staff	Process should follow the basic method described in section 2.2 Table 3 for the baseline inventory of vegetation around each snag; Within an approximately 5 metre radius circle, visually estimate the percent cover of vegetation and list the species present. If known aggressive invasive species are present, prompt intervention is recommended (removal method based on species/size).
Photopoint	During summer (or late spring/ early fall), when vegetation is growing; Suggested every 5 years (starting 2029, or as convenient in preparation for NCC Phase 2 planning) / NCC staff	A photo should be taken in conjunction with each vegetation plot survey. Over time, these will provide comparative visual evidence of site recovery and may be used as tools for public interest and education. See photopoint GPS locations and initial photopoint photos in Appendix A.

Bird Surveys

Monitoring for birds will fulfill objectives towards the goal of increasing knowledge of bird use and visits to the site / Migratory Bird Sanctuary. Over time, bird survey monitoring data, alone or combined with eBird or Breeding Bird Survey data, may point to changes in the bird species visiting the site and population trends. Point count data combined with information on site vegetation changes over time may specifically show how changes in habitat relate to changes in bird species and abundance (see Recommendations for other bird data sources).

Table 10. Bird monitoring scheme

Type of monitoring	When / Who	Methods
General bird counts	During site visits any time of year; / NCC staff, site stewards, and citizens (with some birding experience)	Count all birds observed (seen or heard); keep track of protocol details and enter data into eBird using the NCC site hotspot (https://ebird.org/hotspot/L6140961), as other citizen data of this general type will be available there.
Point counts	Can be done as much as annually during breeding season (based on personnel available), or suggested at least every 5 years coinciding with snag vegetation plot surveys (starting 2029) / NCC staff and citizens (with bird expertise)	Protocol was established by NCC staff (Patrick 2023) and follows the baseline point count survey completed in 2023, described in Methods. Counts should be done at the four established locations, 10 minutes observation at each point (unlimited distance counts); surveys should be completed between one half hour before sunrise to five hours after sunrise, with 2-6 surveys performed during breeding season (minimum six days between counts). NCC maintains an Excel spreadsheet for point counts.
Bird-snag interactions	(See Snag Monitoring)	

4.2 Recommendations

Snag Enhancement

Decisions to add enhancements around snags can be made by NCC staff based on site monitoring, adaptive management strategies, and future site goals. If vegetation regrowth around snags is slow, if seedlings lack vigour, or if it is determined that birds are only minimally using the snags, the following are recommended:

- Add soil or CWD — Decision criteria: Vegetation fails to grow underneath snags that did not have soil added around the base (Snags 1, 4 & 6); Vegetation is growing around both types of snags, but it fails to thrive where there is a lack of soil, or it so obviously is growing much faster around snags with soil.
- Plant bird-attracting native vegetation islands around snags — Decision criteria: Plant diversity is lacking after several years; Introducing new species is desired; Few birds are observed interacting with perches. Shrubs can be a means for increasing overall bird interest in snags and therefore potential seed rain. Shrubs also provide ground cover, and potentially expedite succession by sheltering other vegetation (Gómez-Aparicio et al. 2005). See Table 11.

Table 11. Shrub addition recommendations. Plants were selected for their potential attractiveness to birds, site suitability based on local occurrence (Weatherby & Adams 1945), and habitat descriptions from Boland guides (2012; 2015). This is not a comprehensive list, and nursery availability may limit options.

Serviceberry	*Amelanchier spp.*
Northern Wild Raisin	*Viburnum cassinoides*
Black (Common) Elderberry	*Sambucus canadensis*
Lowbush Blueberry	*Vaccinium angustifolium*
Black Huckleberry	*Gaylussacia baccata*
Smooth Gooseberry	*Ribes hirtellum*
Wild Red Raspberry	*Rubus idaeus*
Chokecherry	*Prunus virginiana*
Canada Plum	*Prunus nigra*
Chokeberry	*Aronia spp.*
Pin cherry	*Prunus pensylvanica*
Mountain ash	*Sorbus americana*

Bird Data Analysis

As the site recovers, bird data directly from monitoring as well as other sources can be used to understand changes in bird populations on the site or to indicate factors of ecosystem health. There are many possible analysis options. For example, a particular species or group of species (such as wood warblers) can be investigated to see whether their abundance is growing in response to the growth of trees in the old quarry over

time; bird species observed during point counts can be tracked for changes in composition in relation to the habitat type or habitat changes at each point. Other sources of bird data which can be drawn upon include but are not limited to:

- eBird (database for citizen observations, most similar type of observation to the general bird counts performed for this project and described in Methods and Monitoring). Site hotspot: Grand Manan—NCC Migratory Bird Sanctuary Nature Reserve https://ebird.org/hotspot/L6140961. The site total species list, as well as individual checklists including protocol details can be viewed. eBird data is most valuable when creating and analyzing "complete" checklists (Johnston et al. 2019).
- Maritimes Breeding Bird Atlas (https://www.mba-aom.ca) conducts breeding bird surveys every 20 years and compiles data from general observations and point counts using standardized protocols. Region 11 (Long Pond Bay) Atlas square 19FK74 encompasses NCC's Migratory Bird Sanctuary conservation site, and within that square, Point #1 is located within the gravel quarry on the NCC restoration site (Maritimes BBA n.d.). The Atlas website contains maps, species lists, and results of previous Atlas surveys.

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APPENDICES

Appendix A. Snag Photopoint Locations and Photos

Snag	Coordinates	Initial Photos, taken September 21, 2023
1	N 44.65623, W 66.77164	
2	N 44.65652, W 66.77163	
3	N 44.65685, W 66.77166	

Snag	Coordinates	Initial Photos, taken September 21, 2023
4	N 44.65702, W 66.77154	
5	N 44.65731, W 66.77154	
6	N 44.65651, W 66.77150	

Appendix B. Site Vegetation List (observations from this project only)

Betula populifolia	Grey Birch	*Vaccinium angustifolium*	Lowbush blueberry
Betula cordifolia	Heartleaf Paper Birch	*Galeopsis tetrahit*	Hempnettle
Betula alleghaniensis	Yellow Birch	*Solidago spp.*	Goldenrod
Picea rubens	Red Spruce	*Chamaenerion angustifolium*	Fireweed
Picea glauca	White Spruce	*Pilosella officinarum*	Mouse-eared Hawkweed
Picea mariana	Black Spruce	*Galium spp.*	Bedstraws
Aronia melanocarpa	Black Chokeberry	*Polypodiopsida*	Ferns
Salix spp.	Willow species	*Spiranthes incurva*	Sphinx Ladies' Tresses
Larix laricina	Tamarack	*Oclemena nemoralis*	Bog Aster
Amelanchier canadensis	Canadian Serviceberry	*Aster spp.*	Aster
Malus sp.	Apples	*Bidens sp.*	Beggarticks
Sorbus americana	American Mountain Ash	*Agalinis neoscotica*	Nova Scotia False Foxglove
Alnus viridis	Green Alder	*Myosotis sp.*	Forget-Me-Nots
Abies balsamea	Balsam Fir	*Nuttallanthus canadensis*	Blue Toadflax
Rubus spp.	Brambles	*Dryopteris spp.*	Wood Fern
Fragaria virginiana	Virginia strawberry	*Pteridium aquilinum*	Bracken Fern
Spiraea alba	White Meadowsweet	*Monotropa uniflora*	Ghost Pipe
Dasiphora fruticosa	Shrubby Cinquefoil	*Scutellaria galericulata*	Marsh Skullcap
Juniperus horizontalis	Creeping Juniper	*Echium vulgare*	Vipers Bugloss
Symphoricarpos albus	Common Snowberry	*Stereocaulon*	Foam lichens
Rhododendron groenlandicum	Labrador Tea	*Ptychostomum pseudotriquetrum*	Long-leaved Thread Moss
Spiraea tomentosa	Steeplebush	*Bryophyta*	Mosses
Reynoutria japonica	Japanese Knotweed	*Polytrichum commune*	Common Haircap Moss
Sambucus sp.	Elders	*Calyptospora columnaris*	Huckleberry Broom Rust Fungus
Ribes hirtellum	Smooth Gooseberry	*Dibaeis baeomyces*	Dibeis Rose

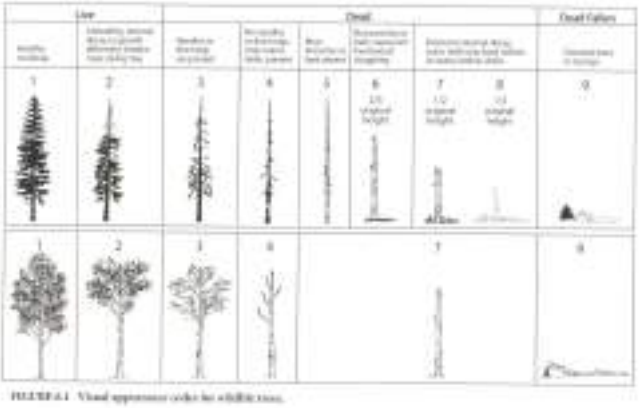
Appendix C. Field Manual Sheets (for reference for future monitoring)

From British Columbia Ministry of Environment, Lands, and Parks and Ministry of Forests. 2010. Field manual for describing terrestrial ecosystems 2nd edition. Land Management Handbook 25. Ministry of Forests, Victoria, BC.

Structural Stages:

Tree Attributes for Wildlife:

Tree Attributes for Wildlife (cont):



Appendix D. Suggested Snag Monitoring Form

Date: Time: Observer name:

Snag locations for reference:

Coordinates:

Snag 1 N 44.65633°, W 66.77202° **Snag 2** N 44.65659°, W 66.77182°
Snag 3 N 44.65696°, W 66.77173° **Snag 4** N 44.65709°, W 66.77166°
Snag 5 N 44.65740°, W 66.77164° **Snag 6** N 44.65663°, W 66.77145°

1. Safety - Note safety concerns, including branches that might be about to fall, general leaning (note degree of lean), other. Sketch or photograph if any concerns.

Snag 1	Snag 2	Snag 3	Snag 4	Snag 5	Snag 6

2. Tree Attributes for Wildlife - Fill out sections below, following Tree Attributes for Wildlife keys or writing general notes/ descriptions.

- Appearance: Assign a number from 1-9 (1=Healthy, no decay; 9=Downed tree/stump) to indicate the appearance of the snag.

Snag 1	Snag 2	Snag 3	Snag 4	Snag 5	Snag 6

- Crown condition: Assign a number from 1-6 (1=All foliage, twigs, and branches present; 6=No branches present; some sound and rotting branch stubs, top broken) or write a description of branch, foliage, and top condition.

Snag 1	Snag 2	Snag 3	Snag 4	Snag 5	Snag 6

- Bark retention: Assign a number 1-7 to indicate the proportion of bark remaining on the snag (1=All bark present; 7=No bark (100% lost) or write a description of bark condition and amount.

Snag 1	Snag 2	Snag 3	Snag 4	Snag 5	Snag 6

- Wood condition: Assign a number 1-8 to classify the soundness of the wood (1=No decay; 8=Hollow shell; outer wood mostly hard or firm) or describe the condition.

Snag 1	Snag 2	Snag 3	Snag 4	Snag 5	Snag 6

- Wildlife use: Note signs of wildlife activity (can use tree wildlife key, or describe activity, including cavity or open nests, resting, feeding, perching/roosting, or other use.

Snag 1	Snag 2	Snag 3	Snag 4	Snag 5	Snag 6

3. Bird-Snag observations - If any bird or birds land on the snag, write the species name and note its behaviour (including singing, calling, feeding (gleaning or sallying for insects), caching food, courting, nesting, or other).

Snag 1	Snag 2	Snag 3	Snag 4	Snag 5	Snag 6