Restoration and management recommendations for Witty's Lagoon Regional Park in Metchosin, BC, with special focus on *Camissonia contorta* habitat

Photo Credit: Maria Varem

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Abstract

Witty's Lagoon Regional Park in Metchosin, BC, comprises a number of different ecosystems and species, including several plant and bird species scheduled under Canada's Species At Risk Act. One of these species is contorted-pod evening-primrose (*Camissonia contorta*), which lives in the coastal sand ecosystem found on the sand spit. Unfortunately, the sand spit and many other areas of the park have been degraded by invasive plants and human activity.

This project has two primary goals: first, to identify and prioritize existing values and threats within the park boundaries, and second, to create a restoration plan for the sand spit. These goals were achieved by following the Open Standards for the Practice of Conservation set out by the Conservation Measures Partnership (CMP).

Ten conservation targets and one human wellbeing target were chosen for the park. Field surveys were conducted to measure various indicators of health for each of the conservation targets. Miradi, CMP's conservation software, was used to conduct viability analyses for each conservation target and threat ratings for the different threats affecting the targets. A situation diagram, which links targets to their threats and other influencing factors, was created for the entire park. Next, potential restoration strategies were identified for the sand spit. A results chain was created in Miradi to illustrate how each strategy would affect the associated targets and what type of activities would be required to achieve the desired restoration results.

This project showcases a successful collaboration between local government, the community, and academic institutions, and offers an excellent example of quantitative, documented restoration planning that combines complex goals into a unified framework.

Acknowledgements

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1.0 Introduction

British Columbia's Capital Regional District (CRD) spans the southern tip of Vancouver Island and the Gulf Islands. The CRD Parks department maintains over 13 000 hectares of land contained by 31 regional parks and 3 regional trails spread across the entire region (CRD, 2013). Many of these parks include critical habitat for rare and endangered species, which makes their management and protection an extremely important task.

One such park is Witty's Lagoon Regional Park in Metchosin. Originally, the land that is now known as Metchosin was inhabited by the Ka-ky-aakan Indigenous tribe and used by multiple Coast Salish groups (Te'mexw Treaty Association, 2020). In 1850, the land was acquired by the Hudson's Bay Company through the Douglas Treaties (Canada.ca, 2013; Te'mexw Treaty Association, 2020), and the area around the lagoon was subsequently sold to private families for farming (MetchosinWeb.ca, n.d.). The park was formally established in 1966 with the purchase of 18 hectares of land from the Witty family (MetchosinWeb.ca, n.d.). Since then, the park has grown to almost 60 hectares. Because of its location along the coast and its long history of farming, Witty's Lagoon Regional Park comprises several different ecosystems, including former orchards, native forests, and coastal ecosystems. These ecosystems support a wide diversity of species, some of which are rare or endangered.

Unfortunately, many areas of the park are currently facing degradation from a number of threats. Invasive plants and human recreational activity are two threats that have previously been identified as causing damage to certain species at risk living within the park boundaries (Golumbia, 2014), but their effects extend beyond just the scope of these species. Due to the interconnected nature of these ecosystems, the best way to protect critical habitat for endangered species within the park is to protect the entire park through invasive species management and ecological restoration. Planning and prioritization are necessary in order to maximize cost effectiveness and the efficiency of restoration activities.

1.1 Study Area Location & Description

Witty's Lagoon Regional Park is located in Metchosin, British Columbia. It is 58.21 hectares in size and is composed of two sections: the main park surrounding the lagoon and a smaller satellite section known as Tower Point (CRD, n.d.) (Figure 1). The main park contains a beach, sand spit, salt marsh, lagoon, and a large forested area of varying stand types, including native coastal Douglas-fir forest stands and abandoned orchards. There are several hiking trails around the lagoon, with a primary trail running from the parking lot on Metchosin Road to the beach, which has a small day-use area with picnic tables. Tower Point has coastal bluffs, a native coastal Douglas-fir forest with small hiking trails, a large open field with picnic tables, and small beach areas across from the sand spit.

Figure 1. *Satellite imagery of Witty's Lagoon Regional Park. Park boundaries are shown in red. The park is split between the main park and a smaller section on the right called Tower Point. Multiple different ecosystem types are visible within the park.*

Two plant species and five bird species found within the park are scheduled under the federal Species At Risk Act (SARA) (Golumbia, 2014), and several other species are ranked as endangered provincially (Appendix A). One of the SARA-listed plants is Howell's triteleia (*Triteleia howellii*); not much is known about it other than that it is most often found in Garry oak ecosystems (Douglas & Penny, 2003). The other SARA-listed plant is contorted-pod evening-primrose (*Camissonia contorta*) (Figure 2), which has been identified by CRD Parks as a priority for conservation action. *C. contorta* prefers sandy backshore habitats with little to no tree or shrub cover and moderate levels of sand erosion and deposition (COSEWIC, 2006; Parks Canada Agency, 2011). Its current habitat in the park is a small section of the sand spit (Figure 3). The coastal sand ecosystem is also a habitat for other rare and unique plants (Golumbia, 2014), including yellow sand-verbena (*Abronia latifolia*), which is on the provincial blue list (B.C. Conservation Data Centre, 2020).

Figure 2. *Contorted-pod evening primrose (Camissonia contorta) at Witty's Lagoon in the early stages of blooming. Photo credit: Maria Varem*

The main threat facing Witty's Lagoon is invasive plants (Page *et al.*, 2011; Golumbia, 2014). The coastal sand ecosystem on the sand spit is almost completely overtaken by Scotch broom (*Cytisus scoparius*), and the field at Tower Point has been severely invaded by black knapweed (*Centaurea nigra*). Other parts of the park, especially along hiking trails, harbour a wide variety of invasive species common to the Pacific Northwest, including Himalayan blackberry (*Rubus armeniacus*), English ivy (*Hedera helix*), and daphne laurel (*Daphne laureola*).

The invasion of *C. scoparius* and other plants on the sand spit has been especially problematic because these species stabilize the substrate (Page *et al.*, 2011). This allows for the formation of a bryophyte crust, which further stabilizes the substrate. The resulting positive feedback loop ultimately causes accelerated ecological succession in an ecosystem that normally wouldn't progress past low-profile herbaceous vegetation (Page *et al.*, 2011). As a result, the coastal sand ecosystem has been degraded to the point that there is now only a narrow strip of suitable habitat left for *C. contorta* (Parks Canada Agency, 2011; Golumbia, 2014) (Figure 3).

Figure 3. *Critical habitat for contorted-pod evening-primrose (*Camissonia contorta*). Red indicates currently occupied habitat; light blue indicates the potential for habitat expansion. Figure adapted from a Parks Canada report on* C. contorta *(Parks Canada Agency, 2011).*

Another threat is human recreation (Page *et al.*, 2011; Golumbia, 2014). Witty's Lagoon is very popular among families and dog-walkers, so there is a lot of foot traffic across the entire park,especially on the beach. This can result in habitat degradation as well as disruption to the local fauna, especially to migratory birds that use the lagoon (Page *et al.*, 2011; Golumbia, 2014). Currently the CRD prohibits off-leash dogs on the beach between June and October, but this is not always strictly enforced.

As forces like invasive plants and human activity degrade the park, rare plants such as *C. contorta*, *A. latifolia*, and *T. howellii* experience population declines (COSEWIC, 2006; Parks Canada Agency, 2011; B.C. Conservation Data Centre, 2020). These and other species are at risk of losing genetic diversity, because smaller populations tend to be more susceptible to effects like bottlenecks or genetic drift (Primack, 2014). Furthermore, if population decline is allowed to continue unchecked, it can result in extirpation of these species from the park entirely.

1.2 Project Goals

This project has two main goals. The first goal is to determine the existing values and threats within the park and prioritize them for future management efforts. The second goal is to create a restoration plan for the sand spit centered around the needs of *C. contorta*.

The objectives supporting the first goal are to use field data to evaluate the conservation threat level of the park, identify key areas where intervention is required, and make general recommendations for future restoration and management. Any data collection methods used must be straightforward and efficient so that they can be repeated in the future by CRD Parks staff or volunteers for monitoring purposes. For the second goal, the objectives are to create a number of draft strategies for restoring the sand spit and to create a detailed restoration action and monitoring plan.

2.0 Methods

The Open Standards for the Practice of Conservation (also known as the "Conservation Standards") set out by the Conservation Measures Partnership (CMP) were used as a roadmap for the project. The Conservation Standards consist of a five-step approach to adaptive management: assess the situation to provide context, plan strategies, implement plans, analyze/adapt management plans as data is monitored, and share the lessons learned over the course of the project (Conservation Measures Partnership, 2020). The first two steps, assess and plan, were used as an approximate guideline to address the project goals.

Ten conservation targets were chosen to represent the full range of different ecosystems and species within the park (Table 1). Later in the project, a human wellbeing target, visitor experience, was added to represent how the community interacts with the park. Each target required a measurable indicator in order to track its viability status; indicators were measured in the field wherever possible in order to get the most current data.

Table 1. *Conservation targets for Witty's Lagoon Regional Park. The type of target refers to whether it is a species-based, ecosystem-based, or human wellbeing target. Indicators represent the health of the target and form the basis of goal-setting for restoration and management. Methods of quantifying the indicators are described in the 'measurements' column.*

Target	**Type**	**Indicators**	**Measurements**	**Data collection**
Coastal sand ecosystem	ecosystem-based	Presence of trees/shrubs, presence of open sand	Percent cover of trees/shrubs, percent cover of open sand	Line transects
Salt marsh	ecosystem-based	Presence of trees/shrubs	Percent cover of trees/shrubs	Line transects
Contorted-pod evening-primrose (*Camissonia contorta*)	species-based	Population size	Number of individuals	CRD Parks' yearly population count
Yellow sand-verbena (*Abronia latifolia*)	species-based	Population size	Total patch area	Population count
Howell's triteleia (*Triteleia howellii*)	species-based	Population size	Number of individuals	Population count
Geyer's onion (*Allium geyeri* var *tenerum*)	species-based	Population size	Number of individuals	Population count
Tower Point field	ecosystem-based	Presence of invasive black knapweed (*Centaurea nigra*)	Percent cover of *C. nigra*	Line transects
Tower Point forest	ecosystem-based	Presence of invasive exotic species	Percent cover of native and exotic species	Line transects
Main hiking trails	ecosystem-based	Presence of invasive exotic species	Percent cover of native and exotic species	Line transects
Bird biodiversity	species-based	Species richness	Number of different species observed per year	Online data from e-Bird
Visitor experience	human wellbeing	-	-	-

Five of the conservation targets were ecosystem-based (coastal sand ecosystem, salt marsh, Tower Point forest, Tower Point field, main hiking trail). For these targets, indicators relating to the presence of wanted or unwanted species were used. For example, the indicator for the Tower Point forest target was the area covered by exotic species, whereas for the coastal sand ecosystem the indicator was the area covered by trees and shrubs. The other five targets were species-based. One of the

targets was bird biodiversity, for which the indicator was species richness. The remaining four targets were each a specific endangered plant: contorted-pod evening-primrose (*C. contorta*), yellow sand-verbena (*A. latifolia*), Howell's triteleia (*T. howellii*), and Geyer's onion (*Allium geyeri* var *tenerum*). Their indicators were all measures of population size.

2.1 Field Data Collection

For the ecosystem-based conservation targets, line transects were used to estimate the percent cover of wanted or unwanted species according to each target's indicator. I sampled roughly 10% of each target's area, with each 10 metres of transect representing 100 m^2 of area sampled, and I split the total sampling length for a given target evenly between multiple line transects per target. Line transect lengths and geographical placements are summarized in Appendix B.

For each line transect, the length intervals along the tape where different plant species intersected the line were recorded. For each interval, I recorded the dominant shrub or undergrowth species. Fully mature trees were not counted except where the line of the transect would pass directly through a wide tree trunk with no other vegetation nearby.

Percent cover was calculated for each indicator:

cover = (total interval length covered by a single species/total transect length for the target)*100

Population size was measured for the four endangered plant targets. *C. contorta*, *T. howellii*, and *A. geyeri* all grow as individual plants and are relatively rare, so they were counted individually. *A. latifolia* forms dense mats due to its long, trailing stems that make it difficult to distinguish individual plants (E-flora BC, 2020). In this case, patch area was estimated rather than counting individuals.

There is a yearly count for *C. contorta* at Witty's Beach hosted by CRD Parks and volunteers, which I attended in 2020. A group of volunteers walked along the spit where *C. contorta* is known to grow and marked individual plants by placing wooden skewers in the sand. At the end of our search, we removed and counted the skewers. For *T. howellii* and *A. geyeri*, I used the BC Species and Ecosystems Explorer online to find the last known locations and population counts for each species, then examined those areas myself with an assistant and counted the number of individual plants we found. To measure patch area for *A. latifolia*, I approximated each patch to a geometric shape and measured the key dimensions to get an estimate of the area for each patch, then added together all of the individual patch areas to get a total cover area estimate.

The indicator for the bird biodiversity target is bird species richness, which was measured using data from eBird on total observed species at Witty's Lagoon from 2015 to 2019.

Data for the human wellbeing target (visitor experience) was not collected because the target was added much later on in the project.

2.2 Miradi Assessments

CMP released Miradi, a conservation software program, as a supplement to support the Conservation Standards. Using the field data collected, I conducted a viability status assessment of the conservation targets in Miradi.

The viability assessment in Miradi requires the user to create four categories for assessing indicator measurements: poor, fair, good, and very good. For each target, I had to determine the value range of the indicators that would apply to each of the four categories (Table 2). I used prior research where possible to inform my decisions. The values for many of the ecosystem targets and the *C. contorta* target were adapted from a similar project undertaken at Sidney spit (Bodson, 2016), and *A. latifolia*'s "very good" range of over 400 m^2 cover was based on the minimum required population to support the endangered sand-verbena moth (*Copablepharon fuscum*). Where research was not available, I made judgement calls based on what seemed reasonable (Table 2). *T. howellii* and *A. geyeri* were the only targets whose value ranges were left blank, but this is not currently an issue because they both have extremely low population counts.

Table 2. *Viability status assessment category value ranges and reasoning. Targets and corresponding indicators are listed in the first two columns. The overall viability status for each target falls under one of four categories: poor, fair, good, or very good. Each category has a range of potential results, and the reasoning for the ranges selected are summarized in the final column.*

Target	Indicator(s)	Poor	Fair	Good	Very Good	Reasoning
Coastal Sand Ecosystem	% cover open sand	<15%	15-20%	20-30%	>30%	Used by Bodson (2016)
	% cover trees/shrubs	>30%	20-30%	10-20%	<10%	Used by Bodson (2016)
Salt marsh ecosystem	% cover trees/shrubs	>30%	20-30%	10-20%	<10%	Used by Bodson (2016)
Camissonia contorta	# individuals	0-1200	1200-1500	1500-3000	>3000	Used by Bodson (2016)
Abronia latifolia	patch area (m^2)	<50 m^2	50-200 m^2	200-400 m^2	>400 m^2	Based on habitat requirements for sand-verbena moth (COSEWIC, 2003)
Triteleia howellii	# individuals	unknown	unknown	unknown	unknown	No information on minimum viable population size available
Allium geyeri var *tenerum*	# individuals	unknown	unknown	unknown	unknown	No information on minimum viable population size available
Tower point field	% cover black knapweed	>30%	20-30%	10-20%	<10%	Adapted from Bodson (2016)
Tower point forest	% cover invasive species	>30%	20-30%	10-20%	<10%	Adapted from Bodson (2016)
Main hiking trails	% cover invasive species	>30%	20-30%	10-20%	<10%	Adapted from Bodson (2016)
Bird biodiversity	# species observed	<50	50-100	100-150	>150	Divided 0-200 into 4 even categories because the maximum number of species ever recorded is 215 (eBird, 2020)

Miradi was also used to carry out a threat assessment. A number of threats to the different conservation targets, such as invasive species, population decline, and trampling, were identified. For each threat-target pair, Miradi prompts the user to evaluate the scope (proportion of target affected), severity (level of damage to the target), and irreversibility (permanence of the damage) of the threat to the target on a four-category scale (very high, high, medium, and low). I selected scope, severity, and irreversibility ratings for each threat-target combination following Miradi's recommendations. The output of the assessment included an overall threat rating for each threat-target pair, each target overall, each threat overall, and for the entire project.

The viability status and threat assessment outputs were used to create a situation model and results chain in Miradi. These two diagrams are visual tools intended to show the relationships between different conservation targets and threats at the project site, and were used as the building blocks for the creation of a detailed restoration plan.

3.0 Results

3.1 Field Data Results

Trees and shrubs accounted for 26% cover in the coastal sand ecosystem and 3% cover in the salt marsh, while low-profile herbaceous vegetation covered 66% of the coastal sand ecosystem and 97% of the salt marsh (Table 3). The coastal sand ecosystem also had 8% cover of open sand (Table 3).

Table 3. *Field results for the coastal sand ecosystem and salt marsh conservation targets. Low-profile herbaceous vegetation and presence of trees/shrubs were indicators for both targets, while presence of open sand was an indicator for the coastal sand ecosystem. Percent cover was measured for all indicators using line transects.*

Target	**Low-profile herbaceous vegetation percent cover (%)**	**Trees/shrubs percent cover (%)**	**Open sand percent cover (%)**
Coastal sand ecosystem	66	26	8
Salt marsh	97	3	-

Native species cover was 85% in the Tower Point forest and 58% along the main hiking trails, while exotic species represented 8% of the cover at Tower Point forest and 37% on the main hiking trails (Table 4). At Tower Point field, invasive *C. nigra* covered 43% of the line transects sampled (Table 4).

Table 4. *Field results for the main hiking trails, Tower Point forest, and Tower Point field conservation targets. Presence of native and exotic species were indicators for the main hiking trails and Tower Point forest targets, while presence of invasive* Centaurea nigra *was the indicator for the Tower Point field target. Percent cover was measured for all indicators using line transects.*

Target	**Native species percent cover (%)**	**Exotic species percent cover (%)**	***C. nigra* percent cover (%)**
Main hiking trails	58	37	-
Tower Point forest	85	8	-
Tower Point field	-	-	43

There were 70 individual *C. contorta* plants counted on the sand spit (Table 5). Eight individuals of *T. howellii* were counted across two populations (Table 5); one population contained 3 plants and was located near the day use area of the beach, while the other population was located at Tower Point and included 5 plants (Figure 4). Zero individuals of *A. geyeri* were found (Table 5).

Table 5. *Population count results for* Camissonia contorta*,* Triteleia howellii*,* Allium geyeri *var* tenerum*, and* Abronia latifolia*. Patch area was recorded instead of number of individuals for* A. latifolia*. Last known locations and dates were retrieved from the BC Species & Ecosystems Explorer (B.C. Conservation Data Centre, 2020). Actual locations found during data collection are noted.*

Species	**Number of individuals**	**Approximate patch area (m^2)**	**Last known location(s) & dates observed**	**Location(s) found**
C. contorta	70	-	Sand spit (2004)	Sand spit
T. howellii	8	-	Main beach south of trailhead, Tower Point coastal bluffs (2014)	Main beach south of trailhead (3 plants), Tower Point coastal bluffs (5 plants)
A. geyeri var *tenerum*	0	-	Tower Point beach (2008)	None found
A. latifolia	-	30	Sand spit, Tower Point beach (2002)	Sand spit only

Figure 4. *Locations of endangered plant* Triteleia howellii *at Witty's Lagoon Regional Park. (A) Three individuals were found behind the day use area at the beach. Approximate location is marked by the yellow star. (B) Five individuals were found on the coastal bluffs at Tower Point. Approximate location is marked by the yellow star.*

Abronia latifolia covered approximately 30 m^2 across seven patches on the sand spit (Table 5). While the BC Species and Ecosystems Explorer indicated a population of *A. latifolia* existed on the beaches at Tower Point, none was found outside of the sand spit.

Data from eBird shows that a total of 215 different bird species have ever been recorded at Witty's Lagoon. From 2015 to 2019, the year with the most bird species recorded was 2017 (157 species), while the least number of bird species were spotted the following year in 2018 (143 species) (Figure 5).

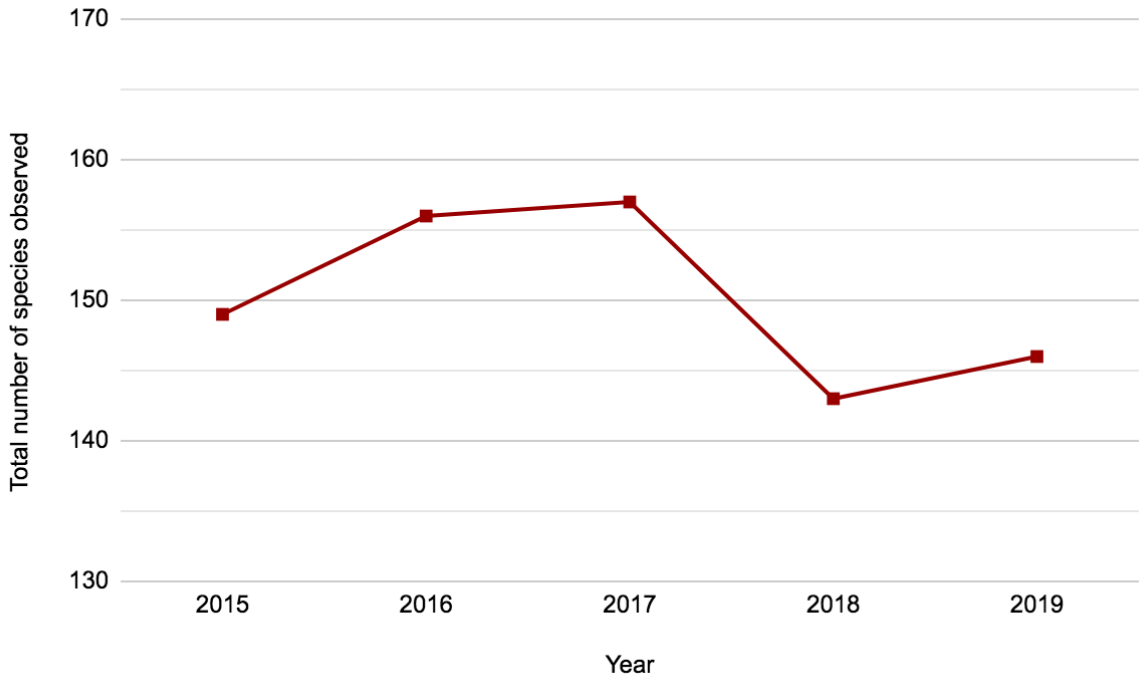

Figure 5. *Bird species richness from 2015-2019. Data obtained from eBird (2020).*

Raw field data was submitted to CRD Parks, and is available through the University of Victoria Restoration of Natural Systems library.

3.2 Miradi Assessment Results

The viability status assessment rated most conservation targets as poor or fair (Table 6). The target with the highest rating was the salt marsh, which was rated "very good". The targets with the lowest ratings tended to be the species-based targets, in addition to Tower Point field and the main hiking trails. While there was no information to determine rating category values for *T. howellii* and *A. geyeri*, common sense dictates that plant population sizes of 8 and 0 respectively would fall under the "poor" category. The coastal sand ecosystem had two different indicators, one of which was rated "poor" while the other was rated "fair". Miradi combined these to give the coastal sand ecosystem an overall "fair" rating. Appendix C contains a detailed version of the viability status assessment directly from Miradi.

Table 6. *Viability status assessment results for each conservation target. Targets and corresponding indicators are listed in the first two columns. The overall viability status for each target falls under one of four categories: poor, fair, good, or very good. The results measured during data collection are listed in the 'indicator measurement' column, and the range of potential results that define each category for each target are listed in the last four columns; bolded values indicate the corresponding result for each indicator measurement.*

Target	Indicator(s)	Target Status	Indicator Measurement	Poor	Fair	Good	Very Good
Coastal sand Ecosystem	% cover open sand	poor	8	**<15%**	15-20%	20-30%	>30%
	% cover trees/shrubs	fair	26	>30%	**20-30%**	10-20%	<10%
Salt marsh ecosystem	% cover trees/shrubs	very good	3	>30%	20-30%	10-20%	**<10%**
Camissonia contorta	# individuals	poor	70	**0-1200**	1200-1500	1500-3000	>3000
Abronia latifolia	patch area (m^2)	poor	30	**<50 m^2**	50-200 m^2	200-400 m^2	>400 m^2
Triteleia howellii	# individuals	poor	8	**unknown**	unknown	unknown	unknown
Allium geyeri var *tenerum*	# individuals	poor	0	**unknown**	unknown	unknown	unknown
Tower Point field	% cover black knapweed	poor	43	**>30%**	20-30%	10-20%	<10%
Tower Point forest	% cover invasive species	very good	8	>30%	20-30%	10-20%	**<10%**
Main hiking trails	% cover invasive species	poor	31	**>30%**	20-30%	10-20%	<10%
Bird biodiversity	# species observed	good	146	<50	50-100	**100-150**	>150

The threats identified during the threat assessment were the following: accelerated succession, invasive plants, population decline, sea level rise, trampling, disruptions to bird activities, and bird habitat degradation. The most dangerous threats are accelerated succession, invasive plants, and population decline, which are all rated "very high" (Table 7). The most threatened conservation target is *C. contorta*, whose threatened level is listed as "very high" (Table 7). The other three endangered plants and the coastal sand ecosystem are the next most threatened targets, each with a threatened rating of "high". The overall project threat rating is "very high".

Table 7. *Summary threat ratings for each threat. The overall rating for each threat represents the degree to which it poses a danger to all of the targets it affects. Threats are listed from most to least threatening. There are four threat levels: very high, high, medium, and low.*

Threat	**Coastal sand ecosystem**	**Salt marsh**	***Camissonia contorta***	***Abronia latifolia***	***Triteleia howellii***	***Allium geyeri* var *tenerum***	**Main hiking trails**	**Tower Point field**	**Tower Point forest**	**Bird biodiversity**		**Summary Threat Ratings**
Accelerated succession	Very High	Low	Very High	High								Very High
Invasive plants	High	Low	Very High	High	Low	Low	High	High	Low			Very High
Population decline			Very High	Medium	Very High	Very High						Very High
Trampling	Low	Low	Medium	Low	High	Medium	Low		Low			Medium
Sea level rise	Medium	Medium										Medium
Bird habitat degradation										Not specified		Not specified
Bird activity disruptions										Not specified		Not specified
Summary Target Ratings	High	Low	Very High	High	High	High	Medium	Medium	Low	Not specified		

3.3 Situation Model

The situation model is a visualization tool in Miradi that combines all of the targets, threats, and contributing factors at the study site so that their relationships can be easily visualized (Conservation Measures Partnership, 2020). The situation model created for Witty's Lagoon Regional Park is shown in Figure 6.

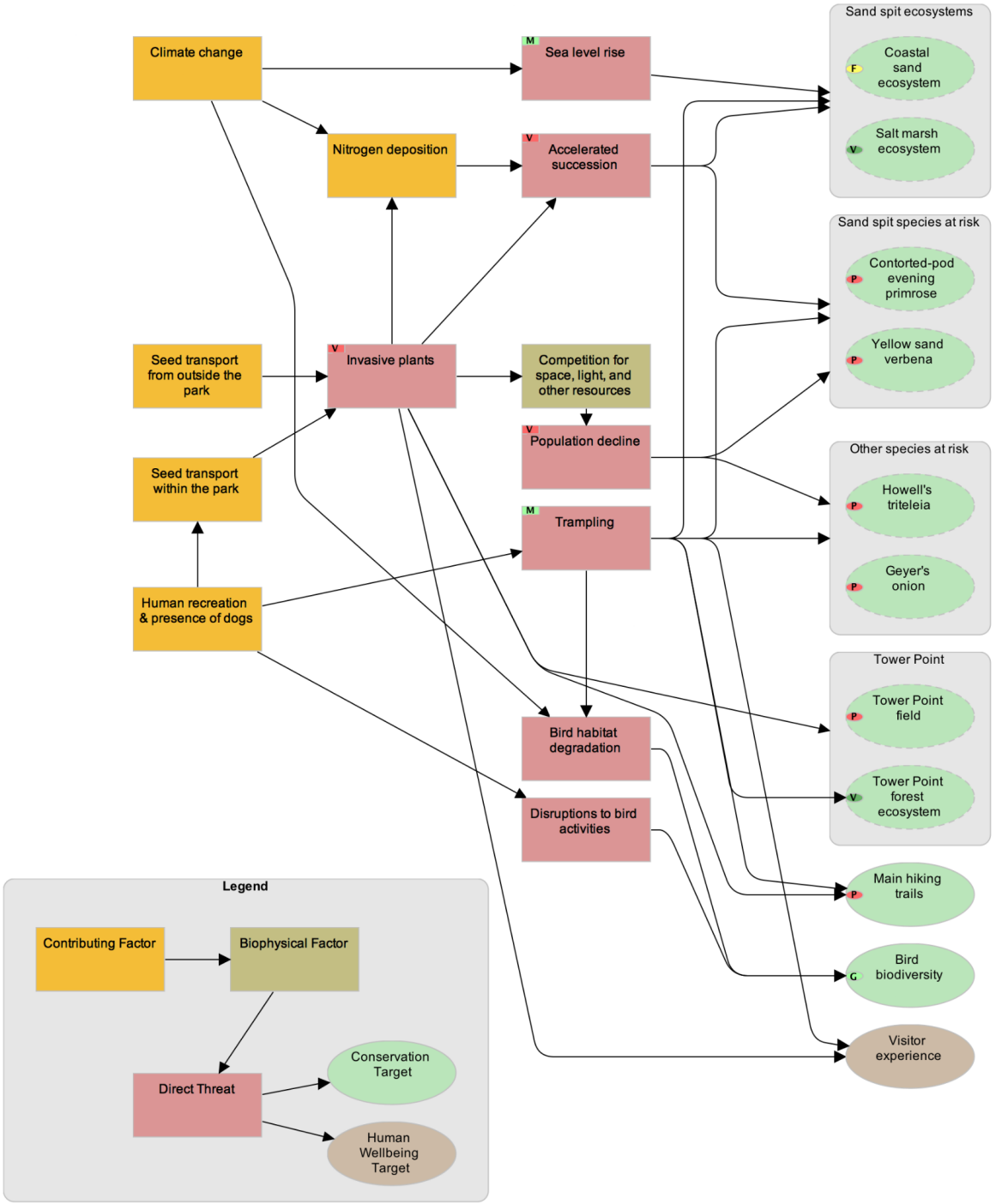

Figure 6. *Situation model for Witty's Lagoon Regional Park, created in Miradi. A situation model is a tool for visualizing connections between the conservation targets and their threats. In this diagram, factors that contribute to threats are shown in orange and brown boxes, threats are shown in red boxes, and the*

conservation targets and human wellbeing targets are shown in green and brown ovals respectively. The arrows connecting the boxes show a flow of causality. The small coloured boxes in the upper left corners of the threat boxes represent the results of the threat assessment in Miradi. Red boxes with a "V" are threats rated "very high", and light green boxes with an "M" are threats rated "medium". The small coloured ovals on the left side of the conservation targets represent the results of the viability status assessment in Miradi. Red ovals with a "P" were assessed as "poor" viability, yellow ovals with an "F" were assessed as "fair", light green with a "G" were assessed as "good", and dark green with a "V" were assessed as "very good".

4.0 Building a Restoration Plan

To address the second project goal (building a restoration plan for the sand spit), I began by focusing on the conservation targets relevant to the sand spit: the coastal sand ecosystem, salt marsh, *C. contorta*, *A. latifolia*, and visitor experience. Using the situation model (Figure 6), several points where it would be possible to intervene and reduce the threats experienced by these targets were identified. For the sand spit, these points were the threat of invasive plants due its high threat ranking and effect on multiple targets, the population decline of *C. contorta* due to its high threat ranking, and the threat of trampling due to its effect on multiple targets. Based on these intervention points, I proposed three overarching strategies for restoring the sand spit: invasive species removal, planting *C. contorta*, and installing exclosures (Figure 7).

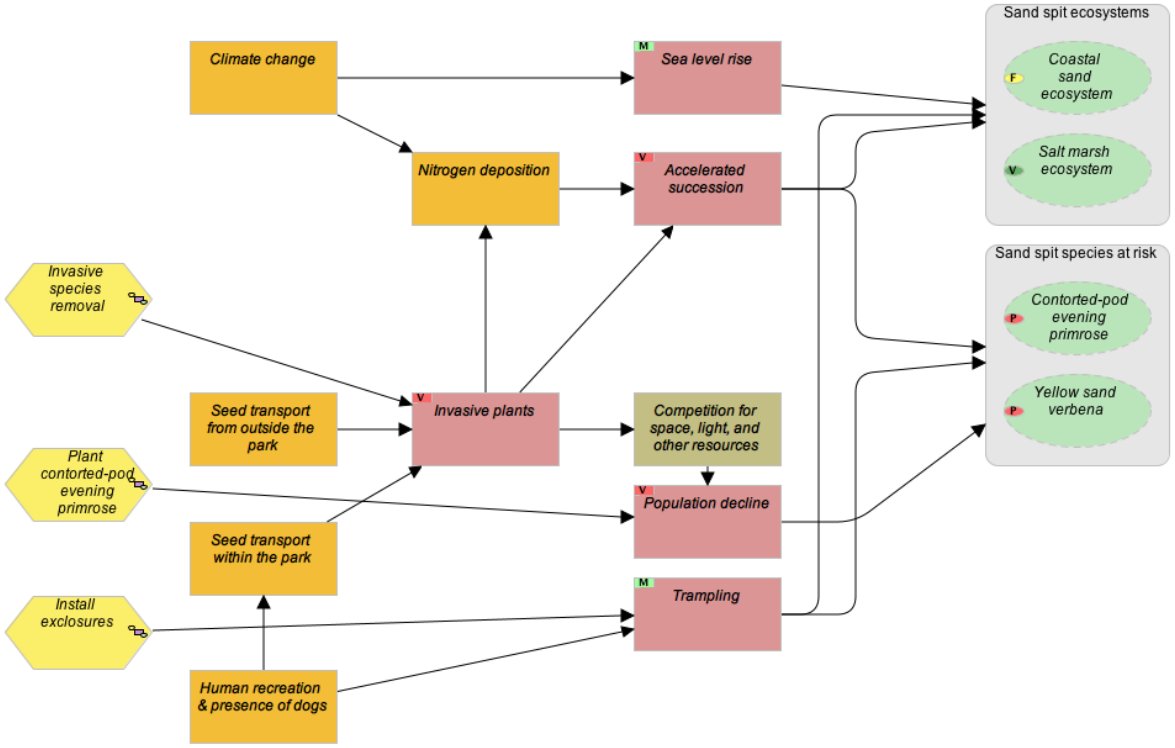

Figure 7. *Situation model showing restoration strategies for the sand spit conservation targets at Witty's Lagoon Regional Park. Boxes have the same meanings as in figure 6, only with the addition of yellow hexagons representing potential restoration strategies. The way the strategies are connected to the rest of the diagram represents intervention points for management efforts within the existing system.*

4.1 Results Chain

In Miradi, a results chain is a solution-oriented permutation of the situation model. Rather than showing the factors and threats negatively affecting the conservation targets, a results chain depicts a theory of change in which various strategies result in positive outcomes for the targets using logical if/then steps (Conservation Measures Partnership, 2020).

After identifying the three strategies for restoring the sand spit, the situation model was converted to a results chain, and steps that would lead to a reduction in the threats were identified (Figure 8). Using the results chain, I determined specific activities required to facilitate the transitions from one step to the next.

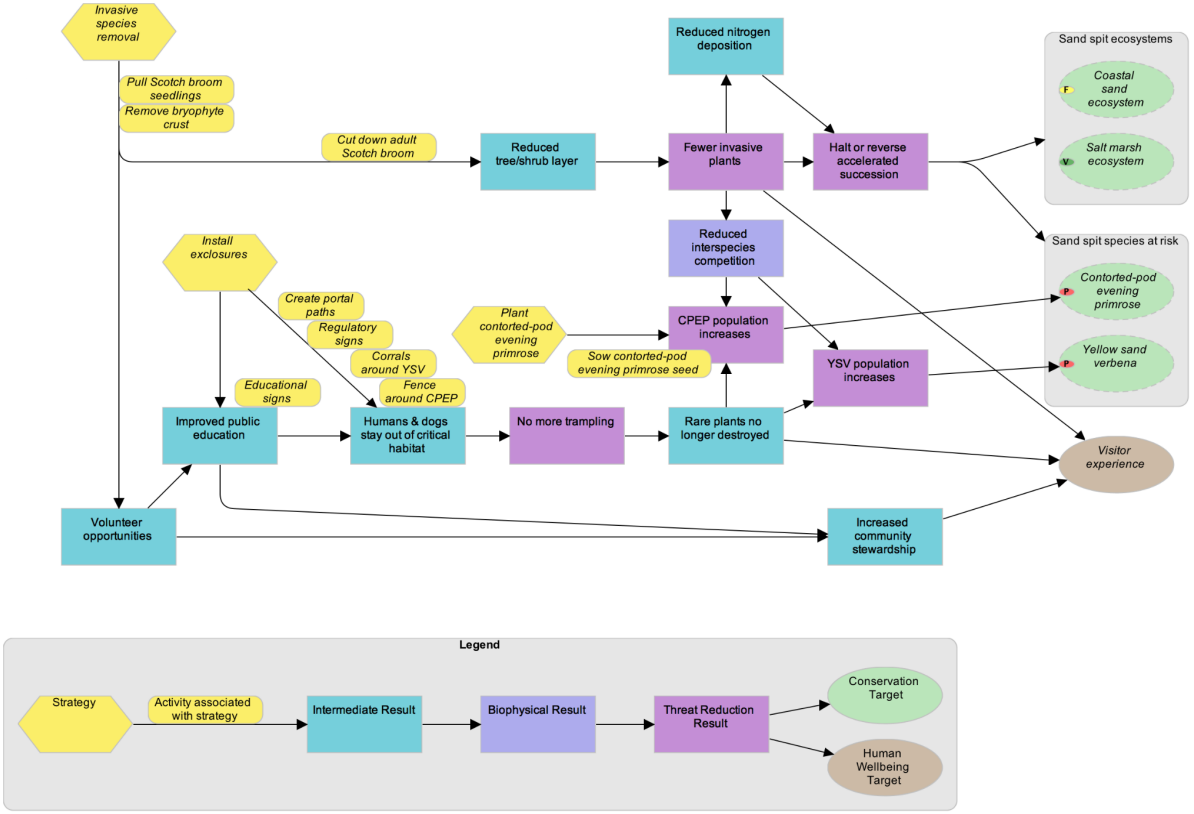

Figure 8. *Results chain for the sand spit at Witty's Lagoon Regional Park, created in Miradi. A results chain is a tool for visualizing how management strategies in the present will lead to desired outcomes in the future. Green and brown ovals represent conservation and human wellbeing targets, as in figures 6 & 7. Blue and purple boxes represent specific results. Arrows represent a flow of if/then logical steps connecting the results. Yellow hexagons represent the same restoration strategies as in figure 7. They are accompanied by yellow boxes depicting specific activities, which clarify what needs to happen to get from one result to the next.*

4.2 Restoration Action Plan

With the results chain serving as a visual guide, I created a restoration action plan outlining all of the strategies and activities to be undertaken, when to take them on, and their resource requirements (Table 8). There are nine restoration activities in total across three strategies.

The first strategy, invasive species removal, involves three primary activities: removing adult *C. scoparius*, removing the bryophyte crust, and yearly hand-pulling of juvenile *C. scoparius* plants. Removal of adult and juvenile *C. scoparius* was suggested for two reasons. First, the removal of adult plants has to be carried out by CRD Parks staff due to the need for power tools such as brush saws, whereas hand-pulling juvenile plants can be done by volunteers (A. Mitchell, personal communication, December 2020). Second, *C. scoparius* seed can live in the soil for an extremely long time before germinating (Huckins & Soll, 2004); while the adult plants can be removed in one sweep, removing juvenile plants will be necessary for at least 5-10 years (Huckins & Soll, 2004) in order to deplete the seed bank. Bryophyte crust removal was recommended because it contributes to substrate stabilization (Page *et al.*, 2011), so its removal is necessary to halt accelerated succession.

The second strategy is to directly plant *C. contorta* in order to boost its population size. This strategy has only one activity: sowing seed. *Camissonia contorta* seed has been sourced via a partnership with Parks Canada (P. Lawn, personal communication, November, 2020).

The third strategy, installing exclosures, involves five different activities: installing a fence around *C. contorta*, installing corralling around *A. latifolia* patches, creating portal paths to the beach, installing regulatory signage, and installing educational signage (Figure 9). Installing a fence around the existing *C. contorta* population will help reduce trampling, but any fencing installed will need to be built to accommodate shifting sands, otherwise it could stabilize the dune and contribute to accelerated succession.

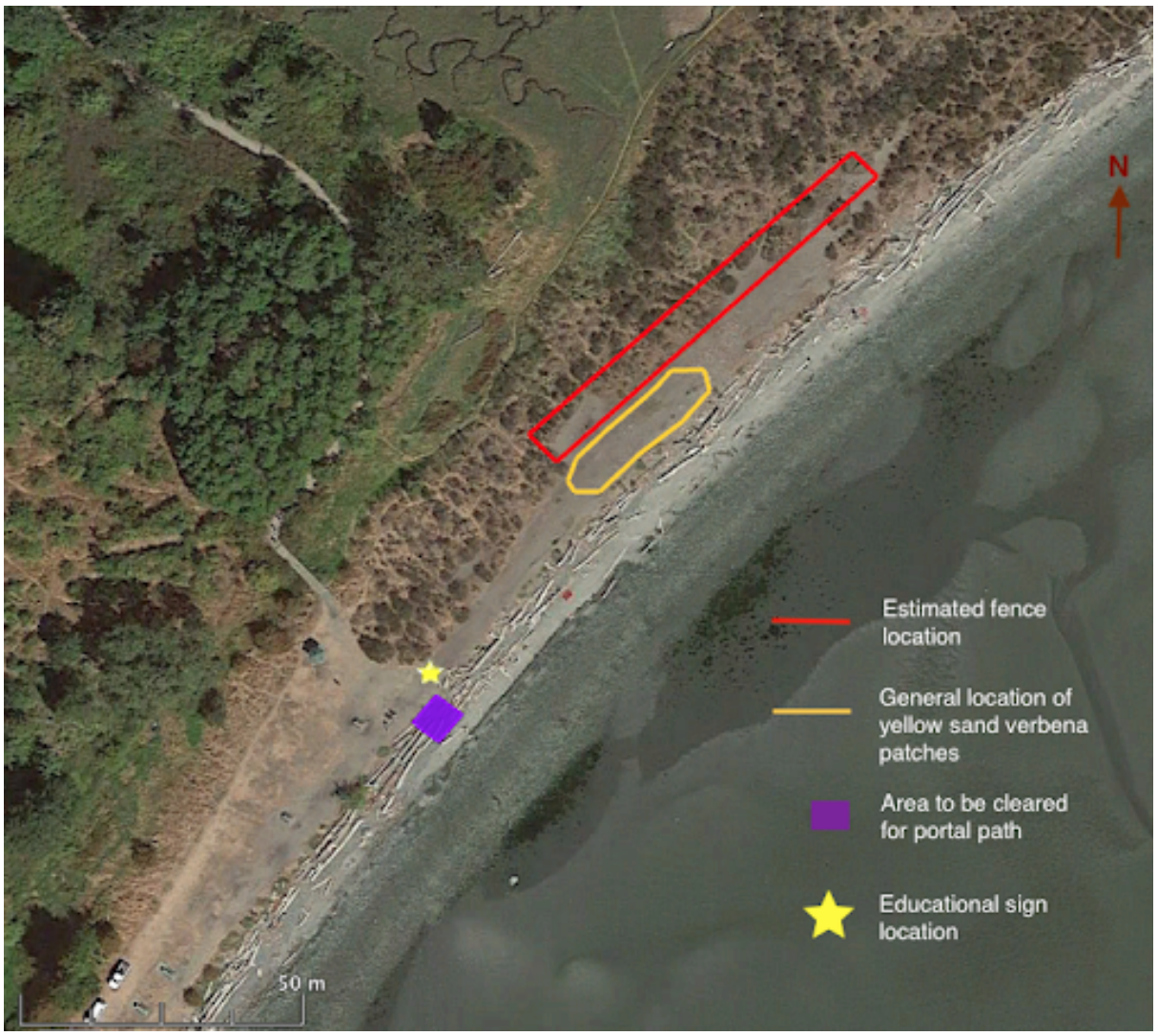

Figure 9. *Map of activities associated with the "install exclosures" strategy. The red line shows the approximate location of where a fence would be installed to protect the current* C. contorta *population. The yellow line shows the approximate area where* A. latifolia *patches currently exist, and thus the general area where corralling would be implemented. Both the fence and the corralled sections would require regulatory signage directing foot traffic. The purple box indicates a section of logs that could be cleared to create a portal path to the beach which would subtly direct traffic away from the endangered plants. The yellow star indicated the ideal location for an educational sign describing the rare plants present on the sand spit and how restoration efforts can help preserve them.*

Corralling is a strategy used in Comox for protecting *A. latifolia* populations from foot traffic (D. Lister, personal communication, 1 October 2020). It involves placing driftwood around individual patches paired with regulatory signage to prevent trampling (Figure 10). It is a low-effort solution that is reasonably effective (D. Lister, personal communication, 1 October 2020), and the driftwood markers can be moved each year as the patches change in size.

Figure 10. *Example of corralling an* A. latifolia *patch at Goose Spit in Comox, BC. Driftwood markers make the patch more visible and easy to avoid, and can also be moved if the patch changes in size. Photo courtesy of Debi Lister from Comox Valley Regional District.*

The creation of a portal path to the beach is intended to subtly direct the flow of foot traffic. Currently, people arriving on the beach from the main trailhead are pushed towards the sand spit and the endangered plants due to the large logs pushed up against the backshore. Removing a 5-10 m section of logs right across from the trailhead would create a clear and easy path directly to the beach and day use area and away from the sand spit (Figure 9).

All exclosures and paths should be paired with regulatory signage directing foot traffic. Regulatory signage should be brief, simple, and clear, and should make use of symbols to emphasize its messages (D. Lister, personal communication, 1 October 2020). Additionally, an educational sign should be installed along the border between the day use area and the sand spit, leading up to the area where *C. contorta* and *A. latifolia* live (Figure 9). This sign should discuss the restoration work being done and the endangered plants and ecosystems being protected in order to spread awareness.

Table 8. *Proposed restoration action plan for Witty's Lagoon Regional park.*

Strategy	Activity	Required Resources	Ideal Completion Time
Invasive Species Removal	Remove adult broom & other invasive plants	● 1-2 days, 5-15 people ● Staff only for cutting down broom, possible space for volunteers to clean up downed broom ● Brush saws (multiple) ● Buckets or tarps for clean-up ● Trucks to haul broom off-site	Early spring 2021 or late summer 2021 - should avoid the breeding bird window (should be done before bryophyte crust removal & fence installation)
	Remove bryophyte crust	● 2 sessions for moss removal: one for around the edge of contorted-pod evening-primrose habitat, another later in the season for the rest of the spit ● Number of days required TBD ● Use volunteers ● Rakes and shovels ● Buckets for clean-up ● Trucks to remove moss off-site	Late spring/early summer 2021 for first session (needs to be done before fence install) Summer 2021 for other sessions Avoid breeding bird window or do nest sweeps
	Hand pull juvenile broom	● One day for several people ● Use volunteers ● Buckets ● Trucks	Summer/fall 2021 (and yearly each summer going forward)
Plant contorted-pod evening-primrose	Sow contorted-pod evening-primrose seed	● Talk to Pippi Lawn	Mid/late fall 2021
Install exclosures	Install fence around contorted-pod evening-primrose	● 1-2 days ● Staff required ● Fence materials	Late summer 2021
	Install corralling around yellow sand-verbena	● An hour or two at most ● 1-2 staff members ● Volunteers can assist if they're around	June/July 2021 (when yellow sand-verbena is blooming)
	Create portal paths to the beach	● One day ● Staff only ● Backhoe or excavator	Any time in 2021
	Install regulatory signage	● Half a day or less for install if signs are moveable	Summer 2021
	Install educational signage	● One day for install	Early summer 2021

4.3 Monitoring Plan

Certain conservation target indicators will need to be surveyed in the long term in order to track restoration progress over time (Table 9). *C. contorta* population counts are already carried out on a yearly basis by CRD Parks and should continue on as normal. I would also recommend adding a survey of *A. latifolia* patch area every 1-2 years. Surveys of vegetation cover on the sand spit, as carried out for the field data collection portion of this project, should be repeated in the future. Future surveys could replicate these initial surveys or use other tactics to measure percent cover, such as aerial photography or visual estimates.

Furthermore, in order to evaluate the success of activities intended to improve the visitor experience target, CRD Parks should consider carrying out a visitor experience survey following the restoration activities detailed in this report. This survey could be repeated in the future to track the effectiveness of public outreach efforts such as volunteer opportunities and educational signs.

In the spirit of adaptive management, the monitoring plan also includes potential future actions that will depend on the results of current restoration activities (Table 9). If *C. scoparius* begins to take over the sand spit again, another round of eradication will be required. If the *C. contorta* population does not increase, sowing seed may need to be repeated. Regulatory and educational signage can be moved around to test ideal locations, and new exclosures could be added if the original ones are not sufficient.

Table 9. *Proposed monitoring actions for Witty's Lagoon Regional Park.*

Desired Future Outcomes	Associated targets	Indicators	Monitoring Activity	Timeframe	Possible Future Actions
Increase contorted-pod evening-primrose population size	*Camissonia contorta*	Population size (number of individuals)	Contorted-pod evening-primrose population survey	Yearly in May (continue existing counts)	If population is not growing, try sowing seeds again in future years
Prevent excessive trampling of contorted-pod evening-primrose	*Camissonia contorta*	Extent of population and signs of trampling damage	Visual survey	Summer every 5 years at minimum	If the contorted-pod evening-primrose population continues experiencing trampling damage, try moving around/creating new regulatory signs, or re-doing the fence
Support other current and future rare and endangered species	*Abronia latifolia*	Yellow sand-verbena population size	Survey yellow sand-verbena patch sizes, adjust corralling as patches grow in size	June/July every 1-2 years	When yellow sand-verbena population size reaches 400 m^2, look into introducing the sand-verbena moth to Witty's Lagoon
Eradicate Scotch broom and other invasive species	Coastal sand ecosystem	% cover of trees & shrubs	Transect survey or visual survey	Survey: Summer every 5 years (starting in 2025) Pull broom: Yearly each summer	If there's no progress, attempt another round of eradication
Prevent excessive trampling of coastal sand ecosystem	Coastal sand ecosystem	Extent of yellow sand-verbena patches, extent of other plant species populations, signs of trampling damage	Visual survey, possible biological inventory of species	Summer every 5 years at minimum	If the coastal sand ecosystem continues to sustain trampling damage, try moving around/adding more regulatory signs, installing more exclosures/barricades, or formalizing a hiking trail around the spit
Restore dynamic processes such as sand movement	Coastal sand ecosystem	% cover of open sand, % cover of trees & shrubs, presence of bryophyte crust	Transect survey or visual survey	Summer every 5 years (starting in 2025)	If a bryophyte crust begins forming again around the contorted-pod evening-primrose habitat, the fence may need modifications to allow for more sand movement.
Educate the public about the natural ecosystems and restoration work taking place	Visitor experience	Visitor knowledge and feelings about the park and their experiences	Visitor survey	Once in 2022 following restoration activities, then every 5-10 years thereafter	Educational signs may require updating at some point
Foster a sense of community stewardship among users of the park	Visitor experience	Visitor knowledge and feelings about the park and their experiences	Visitor survey	Once in 2022 following restoration activities, then every 5-10 years thereafter	Continue providing volunteer opportunities for park visitors

5.0 Discussion

The original goals and objectives of this project were addressed successfully. The chosen field data collection methods were simple and efficient, as intended. Each line transect survey took about half an hour to complete with two people, which allowed for flexibility in planning; future monitoring surveys can easily be undertaken all at once by multiple teams, or over the course of many days by as few as two people. This survey method can be adapted to fit many different situations, regardless of available time or volunteer numbers.

Most of the project objectives related to contextualizing the conservation targets and their threats, and using that context to build a restoration plan for the sand spit. CMP's Conservation Standards and Miradi were highly effective in achieving these objectives. The Conservation Standards encourage users to draft ideas for each step of the process and revisit sections later to flesh them out (Conservation Measures Partnership, 2020). This sets up an incredibly flexible workflow that is especially useful when required information is not immediately available. Additionally, the Miradi software is easy to use and walks the user through every step of the Conservation Standards process and each of the assessments. It also encourages revisiting past ideas through the inclusion of specific features such as a "brainstorm mode" for the situation model. As a result, it was not only possible but very straightforward to evaluate conservation targets and threats, identify key areas for intervention, and create multiple strategies for restoring the sand spit. Creating a restoration plan and placing that plan in a wider context was not an inherently easy task, but the use of Miradi and the Conservation Standards as guidelines made it significantly easier.

5.1 Project Limitations

While the data collection methods proved to be efficient, some of the data collected may not provide a perfectly complete or precise picture of what's happening in the park.

For example, bird species richness is a reasonable indicator of bird biodiversity in general, but with at least five SARA-listed bird species present at Witty's Lagoon, measures of biodiversity are probably too general. Given the importance of protecting endangered species, detailed surveys about those five in particular would have been preferable, such as identifying breeding pairs or counting nests.

Furthermore, population counts for *T. howellii* and *A. geyeri* were carried out at the end of their flowering period, which means individuals could have been missed during my counts. This is especially true for *A. geyeri*; I didn't find any plants, but that doesn't mean they weren't there. Better timing and expert opinion are needed to determine if *A. geyeri* is truly extirpated from the park.

5.2 Future Directions & Recommendations

Despite these limitations, the process of situating a targeted restoration plan within the broader context of the park as a whole was effective overall. Future work could involve specific restoration plans for other sites, such as the Tower Point field, Tower Point coastal bluffs, or subsections of the main park forest. For each area, consideration should be given to whether the ultimate goal will be simply controlling any invasive species present or completely overhauling the area. For instance,

restoration along the hiking trails might focus just on invasive species control, but restoration at the Tower Point field could range from just removing *C. nigra* to completely redesigning the area as a Garry oak savannah.

That said, invasive species control is almost certainly going to be the biggest undertaking moving forward. Eradication of every single invasive species will be impossible, so future management efforts should aim to maintain a controlled environment for most invasive species and prevent the more problematic ones from spreading. However, eradication of some species in certain areas is still possible, and should be the goal wherever it can be achieved. For example, eradication of *C. scoparius* on the sand spit will require years of effort but is certainly possible, especially given that *C. scoparius* doesn't have a strong presence anywhere else in the park. Similarly, *C. nigra* at Tower Point is relatively contained and highly problematic, so it could be another candidate for eradication. Some potential activities for invasive species control include installing boot brushes, establishing community invasive species pull events, updating park signage to raise awareness, and setting up an official line of communication for visitors to report invasive species that they encounter.

Other important goals are the protection of endangered species and the reintroduction of previously extirpated species. The current restoration of *C. contorta* habitat on the sand spit will be beneficial for other coastal sand ecosystem species, but there are endangered species elsewhere in the park that need immediate protection. *T. howellii* is at high risk of being trampled or mowed at its current locations, so a high priority in the short term should be to install exclosures to protect it. In the long term, as restoration efforts increase across the park, future management efforts could involve the reintroduction of deltoid balsamroot (*Balsamorhiza deltoidea*) (which was formerly recorded at Witty's Lagoon and has since been extirpated [Golumbia, 2014; B.C. Conservation Data Centre, 2020]), *A. geyeri* if it is truly extirpated now, and *A. latifolia,* specifically on the Tower Point beaches. Reintroductions could be achieved through sowing seed or by directly transplanting individuals from other locales where appropriate. Additionally, if the main *A. latifolia* population on the sand spit is able to grow in size to cover at least 400 m^2, it could be possible to introduce the critically endangered sand-verbena moth (*C. fuscum*) to the coastal sand ecosystem (COSEWIC, 2003). Further research into endangered bird species that use the park is also required in order to create a robust plan for their protection.

Finally, a key action in achieving any future management goals is community stewardship of the park. Restoring Witty's Lagoon Regional Park will require buy-in from many different stakeholders and assistance from volunteers. Input from the surrounding community and park visitors about what they value in the park and how they envision its future will be vital to informing any future restoration and management efforts.

Community engagement should also include partnerships with Indigenous groups, in particular the groups included in the Te'mexw Treaty Association. It is unclear what happened to the Ka-ky-aakan band after their land was sold in the Douglas treaties; some sources list them as part of the modern Beecher Bay (SĆIA⁄NEW) band (Wikimedia Foundation, 2021), while others suggest they left to join the Songhees nation (MetchosinWeb.ca, *n.d.*). Regardless, any restoration efforts should be inclusive of surrounding First Nations groups, which include the current Songhees, Beecher Bay, T'Sou-ke, and Malahat nations from the Te'mexw Treaty Association (Te'mexw Treaty Association, 2020), as well as

groups within the W̱SÁNEĆ nation (W̱SÁNEĆ Leadership Council, 2020). Restoration is one of many ways Indigenous groups today engage in cultural revitalization (Corntassel & Bryce, 2011), and restoration practitioners need to be aware of the colonial history of the land they are trying to restore. The CRD has committed to reconciliation with First Nations groups residing on southern Vancouver Island (CRD, 2019), so including Indigenous groups in restoration activities will be a key action in upholding that commitment.

6.0 Conclusion

Witty's Lagoon Regional Park in Metchosin, BC, is a very large park containing a wide variety of different ecosystems and species, including several rare and endangered species in need of protection. The two goals of this project were to characterize the existing conservation values across the whole park and to create a restoration plan for the sand spit. The sand spit was given priority for restoration because it is home to *C. contorta*, a federally endangered plant that lives only in coastal sand ecosystems. Some of the conservation targets were found to be in good condition or experiencing low levels of threat, but most conservation targets were found to be in poor condition and highly threatened, including *C. contorta* and the coastal sand ecosystem in which it lives. The restoration action plan for the sand spit revolves around three primary strategies: removing invasive species, planting *C. contorta*, and installing exclosures.

Future park management efforts could attempt similar targeted restoration plans for specific areas and species within the park, and there is potential to introduce other endangered species that normally inhabit similar ecosystems as those at Witty's Lagoon. Moving forward, visitor engagement will be key to success, as support and stewardship from the surrounding community are some of the best ways to ensure that a restored area continues to be taken care of into the future.

7.0 References

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8.0 Appendices

Appendix A: Endangered species present at Witty's Lagoon Regional Park. Adapted from Golumbia, 2014.

	Species	**Common name**	**SARA Schedule 1 status**	**BC list status**
	*Camissonia contorta*	Contorted-pod evening-primrose	endangered	red
	*Triteleia howellii*	Howell's triteleia	endangered	red
	*Abronia latifolia*	Yellow sand-verbena	-	blue
	*Allium geyeri* var *tenerum*	Geyer's onion	-	blue
	*Brachyramphus marmoratus*	Marbled murrelet	threatened	blue
	*Contopus cooperi*	Olive-sided flycatcher	threatened	blue
	*Falco peregrinus anatum*	Peregrine falcon	special concern	red
	*Patagioenas fasciata*	Band-tailed pigeon	special concern	blue
	*Ardea herodias fannini*	Great blue heron	special concern	blue
	*Hirundo rustica*	Barn swallow	-	blue
	*Ptychoramphus aleuticus*	Cassin's auklet	-	blue
	*Branta bernicla*	Brant	-	blue
	*Fratercula cirrhata*	Tufted puffin	-	blue
	*Progne subis*	Purple martin	-	blue
	*Phalacrocorax penicillatus*	Brandt's cormorant	-	red
	*Uria aalge*	Common murre	-	red
	*Phalacrocorax auritus*	Double-crested cormorant	-	blue
	*Hydroprogne caspia*	Caspian tern	-	blue

Appendix B: Line transect locations and lengths

Transect	Associated Target	UTM zone	UTM easting	UTM northing	Bearing	Length
1	Coastal sand ecosystem	10U	461936	5359194	340	40
2	Coastal sand ecosystem	10U	461997	5359270	320	40
3	Coastal sand ecosystem	10U	462155	5359341	315	40
4	Salt marsh	10U	461993	5359307	265	120
5	Tower Point field	10U	462475	5359260	208	60
6	Tower Point field	10U	462415	5359185	10	60
7	Tower Point field	10U	462394	5359258	200	60
8	Tower Point forest	10U	462455	5359228	111	50
9	Tower Point forest	10U	462463	5359140	106	50
10	Tower Point forest	10U	462516	5359186	101	50
11	Tower Point forest	10U	462561	5359252	120	50
12	Main hiking trails	10U	462003	5359523	305	60
13	Main hiking trails	10U	461780	5359281	310	60
14	Main hiking trails	10U	461332	5359498	145	60
15	Main hiking trails	10U	461433	5359611	75	60
16	Main hiking trails	10U	461806	5359748	220	60

Appendix C: Detailed viability status assessment results in Miradi

Item	Status	Poor	Fair	Good	Very Good
01. Coastal sand ecosystem	Fair				
Ecosystem quality	Fair				
Open sand cover	Poor	less than 15%	15–20%	20–30%	more than 30%
2020-06-20: 8		8			
Trees and shrubs	Fair	over 30%	20–30%	10–20%	under 10%
2020-06-20: 26			26		
02. Contorted-pod evening primrose	Poor				
Population size	Poor				
Number of individuals	Poor	0–1200	1200–1500	1500–3000	3000+
2020-05-07: 70		70			
03. Yellow sand verbena	Poor				
Population size	Poor				
Population area	Poor	less than 50 m2	50–200 m2	200–400 m2	more than 400 m2
2020-06-25: 30		30			
04. Salt marsh ecosystem	Very Good				
Ecosystem quality	Very Good				
Trees and shrubs	Very Good	over 30%	20–30%	10–20%	less than 10%
2020-06-20: 3					3
05. Howell's triteleia	Poor				
Population size	Poor				
Number of individuals	Poor	unknown	unknown	unknown	unknown
2020-05-26: 8		8			
06. Geyer's onion	Poor				
Population size	Poor				
Number of individuals	Poor	unknown	unknown	unknown	unknown
2020-05-26: 0		0			
07. Tower Point field	Poor				
Presence of invasive species	Poor				
Black knapweed cover	Poor	over 30%	20–30%	10–20%	less than 10%
2020-07-17: 43		43			
08. Tower Point forest ecosystem	Very Good				
Ecosystem quality	Very Good				
Invasive plant species cover	Very Good	over 30%	20–30%	10–20%	less than 10%
2020-07-06: 8					8
09. Main hiking trails	Poor				
Ecosystem quality	Poor				
Invasive plant species cover	Poor	over 30%	20–30%	10–20%	less than 10%
2020-08-26: 31		31			
10. Bird biodiversity	Good				
Species richness	Good				
Number of species observed	Good	<50	50–100	100–150	>150
2019-10-19: 146				146	