Pacific Crab Apple Restoration at Kwiid Suu (Mayer Lake) on Haida Gwaii

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ER390 Final Report

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Abstract

Pacific crab apple (*Malus fusca*) is a plant of both cultural and ecological significance on Haida Gwaii. At Kwiid Suu (Mayer Lake), populations of Pacific crab apple have been severely reduced since the introduction of the American beaver (*Castor canadensis*) and Sitka black tail deer (*Odocoileus hemionus sitkensis*). Beaver feed on the inner cambium layer of trees, often girdling them in the process, and fall stems to build their dams; while deer browse limits the recruitment of young crab apple. The rapid decline of crab apple at Kwiid Suu was first observed in 2000, leading to a series of beaver control and riparian plant protection projects. Through the spring and summer of 2022, I observed 178 mature crab apple trees across 10 plots to gather data on the health of the remaining groves. I also counted the number of stumps, felled trees, and gathered information on recruitment by recording the abundance of seedlings and young trees within the plots. A total of 160 felled trees were recorded within the surveys and the majority of standing mature trees had signs of beaver chewing. Despite this heavy impact from beaver, crown dieback was low in 58% of trees surveyed and fruit production was generally consistent with observations elsewhere on Haida Gwaii. Regeneration was recorded as high or moderate in 80% of plots, however, seedling survivorship appeared to be very low with only 27 young trees found within the plots. Based on these results, I constructed a total of 21 exclosures that focused on protecting seedlings. I built four large crab apple exclosures that protected a mature crab apple tree along with seedlings or shoots growing around its root mass, and 17 cone exclosures around individual seedlings or bunches of shoots. The surveys have highlighted an extreme lack of crab apple recruitment. In some of the larger groves where mature trees can support regeneration, seedlings should be protected by exclosures. In areas where mature trees are no longer existent, seedling may need to be planted on site with protection.

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1.0 Introduction

Pacific crab apple (*Malus fusca*) is a culturally and ecologically significant plant on Haida Gwaii, that once grew in abundance within the riparian area of Kwiid Suu (Mayer Lake) (Golumbia et al, 2008). However, impacts from invasive species have severely reduced the competitive advantage of Pacific crab apple, and its ability to regenerate, causing the plant to become much less common in the area (Miller, Cheney, and Mars, 2003). Browsing pressure on Pacific crab apple comes from two introduced vertebrates on Haida Gwaii: Sitka black-tail deer (*Odocoileus hemionus sitkensis*), and beaver (*Castor canadensis*).

In 2000, it was observed that crab apple trees at Kwiid Suu were rapidly losing their competitive advantage due to beaver and there was a lack of young recruitment, likely attributed to deer (Vanderstar and Joseph, 2000, as cited in Dickson and Moore, 2021). Two beaver management plans have been produced for the Kwiid Suu watershed since. The first was composed by Northern Graham Island Streamkeepers in 2003 (Miller, Cheney, and Mars 2003). The second was by Laskeek Bay Conservation Society, which updated and expanded on the plan from 2003 (Dickson and Moore 2021). Both management plans recommended riparian plant protection and restoration, along with baseline data collection, and beaver control.

Through February and March of 2022, crews from Laskeek Bay Conservation Society, BC Parks, and the Council of the Haida Nation (CHN) constructed 32 exclosures around mature Pacific crab apple trees at Kwiid Suu. Due to time and funding constraints, exclosure construction was halted in March. For this ER390 project, my objectives were to continue with exclosure construction, and collect data on health and regeneration at some of the remaining Pacific crab apple groves.

2.0 Background

2.1 Pacific Crab Apple

Pacific crab apple is a small shrub or tree that is adapted to the wetlands, riparian areas, and estuaries of Haida Gwaii. It is a shade intolerant species that prefers nutrient rich soils (Pojar and Mackinnon, 1994). In forested areas, it is often out competed by conifers if site conditions permit. Pacific crab apple can be single or multi-stemmed and is often sprawling. It is generally 2-12m tall and is armed with sharp spur shoots (Pojar and Mackinnon 1994). It has white to pink showy blossoms and reddish fruits when ripe that grow in clusters. The fruits are tart, crisp, and juicy, becoming sweeter with age and storage (Turner, 2004). Pacific crab apple is most closely related to crab apple species native to Asia and China rather than other North American taxa, and is therefore believed to be a recent migrant across the Bering Strait (Routsen et al, 2012).

At Kwiid Suu, crab apple can be seen growing along the shoreline as well as in the adjacent forested area, especially within canopy gaps. With low floral diversity on Haida Gwaii, Pacific crab apple is likely important to forest functional diversity and structural complexity, as it is one of the few deciduous trees in the conifer dominated landscape. The fruits are an important food source for birds and bears.

Pacific crab apple is used by 33 Indigenous groups along the west coast of North America (Wyllie de Echeverria, 2010). Many Indigenous groups cared for orchards near villages or seasonal camps (Wyllie

de Echeverria, 2010). The word for Pacific crab apple is *k'ayanhla* in the Masset dialect of the Haida language and is of great cultural importance to the Haida (Turner, 2004). Crab apple is a class two Haida Traditional Forest Feature within the *Haida Gwaii Land Use Objectives Order* (HGLUOO, 2014). Under the order, sufficient stand level retention must be provided to protect the integrity of at least 50% of crab apple in a development area.

Pacific crab apple was traditionally picked in the fall and stored in water in bentwood boxes with a layer of oil on top (Turner, 2004). They kept well in this fashion, getting sweeter throughout the winter. When they were to be eaten, the boxes would be drained and the fruits would be de-stemmed. They would then be mixed with euclochen grease and eaten, often served at feasts (Turner, 2004). The wood of crab apple is very strong and resilient, and was used for tools and digging sticks. The bark was used in a variety of ways for medicine (Turner, 2004).

Today, Haidas and non-Haidas alike will visit Kwiid Suu to collect Pacific crab apple fruits in the fall and early winter. Crab apple fruit is often turned into jellies, jarred with syrup, or simply frozen whole.

2.2 Site description

Kwiid Suu, part of Naikoon Provincial Park, is located on Haida Gwaii, an archipelago located 50km off the mainland coast at its closest point, and the traditional territory of the Haida Nation. It is located within the Queen Charlotte Lowland physiographic region of Haida Gwaii, and is classified as Coastal Western Hemlock wet hypermaritime (CWHwh) biogeoclimatic zone and subzone. The lowlands are characterized by poorly drained wetlands and scrub forests. Raised *Sphagnum* bogs with stunted shore pine are the most widespread wetland type within the region, with more productive sites generally found within riparian areas (Banner et al, 2014).

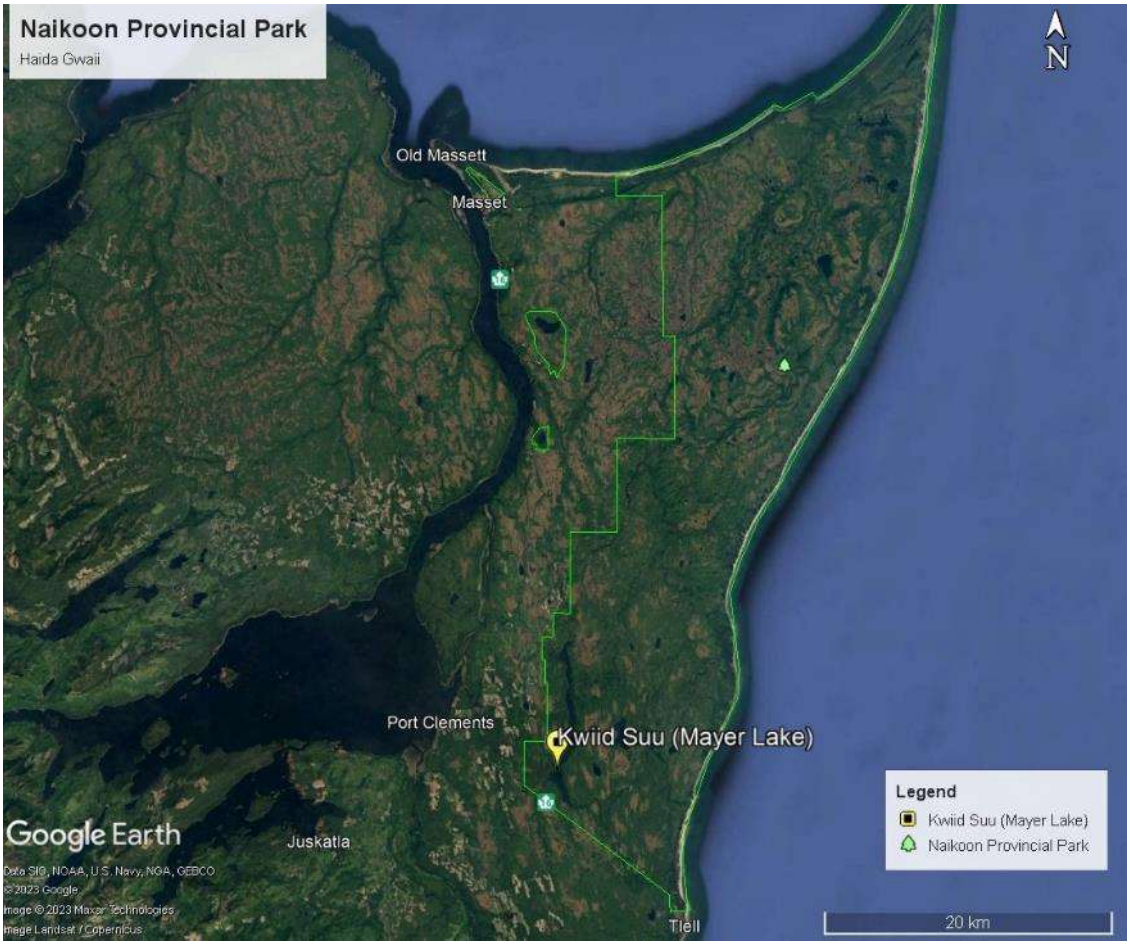

Figure 1 Naikoon Provincial Park and Kwiid Suu

At 489 ha, Kwiid Suu is the largest lake in Naikoon provincial park. It is 11km in length running north to south, and is less than 1km wide at its widest point. The lake is shallow, with an average depth of 2.6m and very acidic (Ph 4-5) (Reimchen 1992). The watershed drains 14,350ha, with approximately 116 km of streams and 7 lakes/ponds (Miller, Cheney, and Mars 2003). Copp Creek, Woodpile Creek and Gold Creek are the major inlets, and the Mayer River is the major outlet. The watershed is low and flat, creating slow moving, meandering rivers, with dark water stained by organic compounds.

2.3 Invasive Species

First introduced to Haida Gwaii in the late 1800s, then again in 1911, it is now estimated that there are an average 13-33 individual deer per km^2 across the archipelago (Golumbia et al, 2008, Stroh et al, 2008). Sitka black tail deer have dramatically altered forest composition and structure throughout all of Haida Gwaii. The understory has become very sparse, and much less diverse than equivalent sites elsewhere on the coast of British Columbia (Banner et al, 2014). At Mayer Lake, young crab apple seedlings and saplings below browse height are heavily targeted by Sitka black tail deer, limiting the ability of young crab apple to reach maturity (Chris Ashurst, Personal Communications, 2022, Miller et al

2003). Deer exclosures have been used extensively throughout Haida Gwaii for research, forestry, educational purposes, and to protect culturally important food plants in select areas (RGIS, 2002).

Beavers were first introduced to Haida Gwaii in 1936 in response to requests from local trappers (Golumbia et al, 2008). Then, in 1949, eleven more beavers were taken from Vancouver Island and released directly into the Kwiid Suu watershed at Gold Creek in 1949 (Miller Cheney and Mars, 2003). Although now thought to occupy virtually all low-lying areas of Graham Island, they are most numerous in areas within or adjacent to the ideal habitat of Naikoon Provincial Park (Golumbia et al, 2008). There are an estimated 50-70 individual beavers within the Kwiid Suu watershed (Miller et al, 2003). Beaver feed on the inner cambium layer of Pacific crab apple and fall mature stems to build their dams. There is also potential for beaver to kill Pacific crab apple and other lakeside plants through flooding, however, the general consensus is that this is not occurring at Mayer Lake (Golumbia et al, 2008, Dickson and Moore 2021).

Both beaver and deer lack predators on Haida Gwaii, allowing their populations to increase without control. Wolves are the main predator for both species (Kirchhoff and Person 2008, Nitsche 2016), and without them, humas are the main cause for population control. Browsing pressure from deer is shown to be reduced in areas of Haida Gwaii where hunting pressure is high (Vourc'h, Escarre, and Martin, 2008). Beaver, however, receive little to no commercial or recreational hunting pressure since the decline of the fur trade.

Figure 2 A Beaver burrow lined with salal at the north end of the lake (left) A freshly chewed Pacific crab apple stem (right) (Photos Ravi Camire 2022)

2.4 Previous Work

Crab apple restoration was first attempted at Kwiid Suu in 2001 and 2002 by the Northern Graham Island stream keepers (Dickson and Moore, 2021). They used chicken wire to make protective collars for individual crab apple stems, and larger exclosures to protect small groups of trees. Over 300 crab apple trees were protected in total. The wire collars are still in place and are thought to be functional to some degree, however, the larger exclosures fell in to a state of disrepair and were removed by BC Parks

(Dickson and Moore, 2021). Additionally, 560 crab apple fruits were reportedly collected and planted during this time, and 11 discs were cut for ring counting. There is no follow up report for this project, so it is unclear if any seedling were grown and transplanted, or if ring counting was done (Dickson and Moore 2021). The exclosures constructed by BC Parks, Laskeek Bay Conservation Society and the CHN during the spring of 2022 was the first attempt at crab apple protection since the 2001 project.

Beaver trapping occurred at Kwiid Suu during the early 2000s by Lenny Morgan, a local resident of Haida Gwaii. Over a sixteen-year period, Lenny removed approximately 15 beavers (Dickson and Moore, 2021). Trapping was recently re-initiated by Jonas Prevost with the CHN's Heritage and Natural Resource Department. During March of 2022, Jonas trapped and killed four beavers (Prevost 2022).

3.0 Goals and Objectives for ER390 Final Project

1. To improve our understanding of the health and recruitment of Pacific crab apple at Kwiid Suu

Objectives

- Conduct surveys at some of the remaining groves to gather data on mature crab apple health, recruitment and impacts from invasive species

2. To increase crab apple recruitment

Objectives

- Construct small exclosures to protect crab apple seedlings and shoots
- Construct large exclosures to protect fruiting mature crab apple along with regeneration at the roots and drip line

4.0 Methods

4.1 Survey

To better understand the health and regeneration patterns of Pacific crab apple groves along Mayer Lake, I took plot samples at 10 groves within the study area. I visited the site three times during May 2022 to monitor flowering, as I suspected groves would be easier to locate while in bloom. On May 29th, most of the crab apple on the eastern shore, and some of the more exposed trees on the western shore were flowering. I conducted a survey of the study area by boat to locate potential plot sites. From the water, groves in bloom were easily identifiable. Plants without flowers stood out less but were still identifiable by their light green patches of foliage which stood out against the darker conifers. When a crab apple grove was located, I marked it as a potential plot site on the cellular app Gaia GPS. I then landed at each potential site to record information on the size and density of the grove based on visual estimates, as well as aspect and canopy closure. Ten plots were chosen to spatially represent the study area as best as possible (long stretches of the lakeshore had no crab apple groves), and to provide a variety of light conditions as this is a variable that may greatly affect crab apple health and productivity. Groves that had been previously selected for exclosure construction this year or back in 2001 were also prioritized to direct resources at common sites.

On June 22nd and June 27th, I took plot samples at the selected groves. Plots were created not to compare results between plots, but to collect cumulative data for the study area in an efficient way. A 20mX20m plot was laid out with a measuring tape reel and flagging tape. Plots started at the highwater line and ran back 20m, often into the closed canopy. Data was collected on field forms which I created prior to coming into the field. I walked the length of the plot back and forth at one meter transects to collect data on mature trees, young trees, regeneration abundance, and stumps/dead trees. Trees were flagged after observation so that they would not be recorded twice.

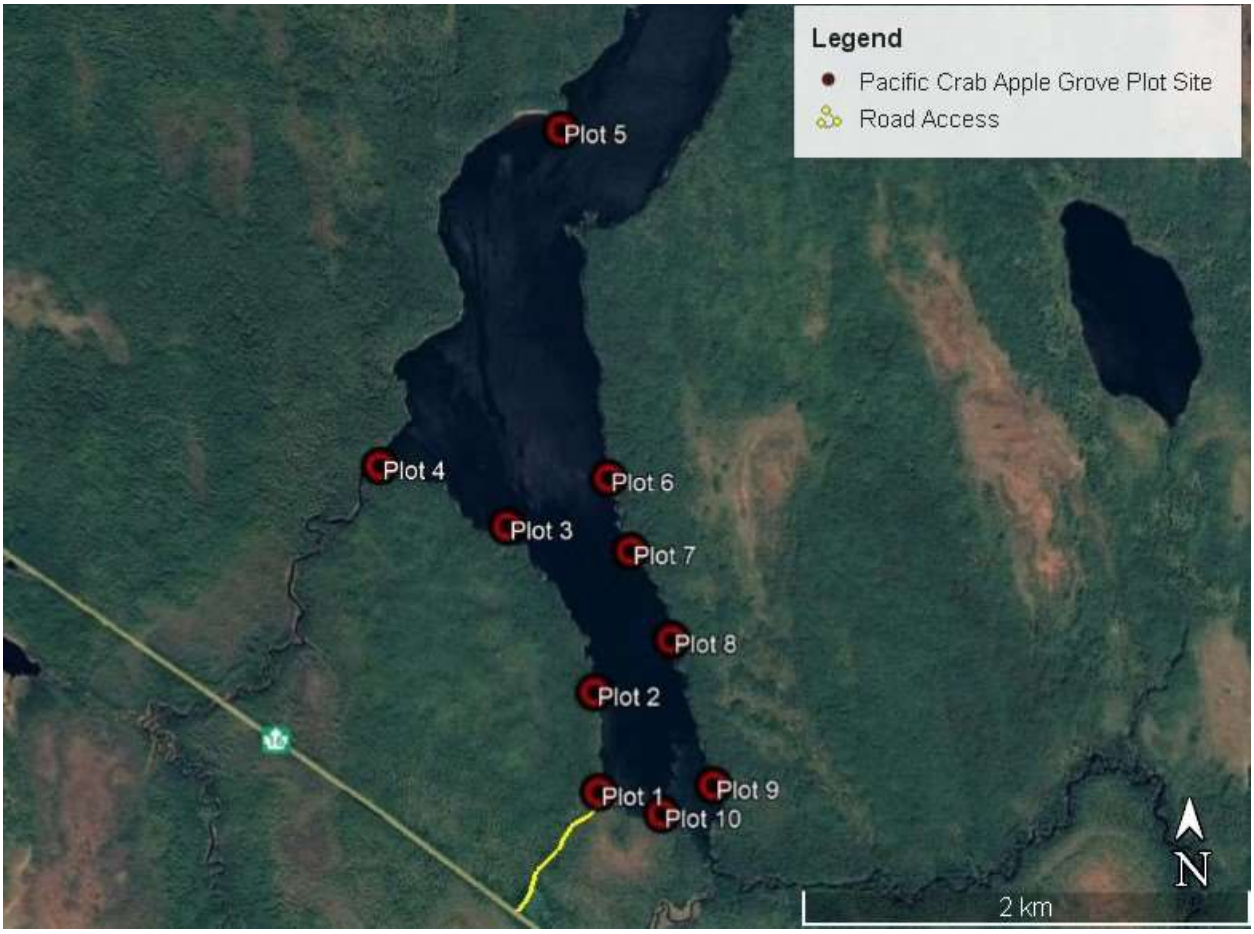

Figure 3 Pacific crab apple groves chosen for plot surveys. Map Centre 53°39'7.11"N 132° 2'37.77"W

Mature Trees

For mature trees, I collected data on four measures: diameter at breast height (DBH), evidence of beaver, crown dieback, and fruit production. DBH was taken with a reel tape by dividing the circumference by pi. Where trees were multi-stemmed, the DBH was taken for each stem and an average stem DBH was recorded. For trees growing horizontally along the ground, a measurement was taken 4.5 feet along the stem.

Evidence of beaver was a visual observation, generally at the base of the trunk. I recorded whether the tree had been chewed by beaver, and whether the chew marks were old or new. Old chew marks were gray with decay, while new chewing still had brown woody color.

Crown dieback was a percentage of the crown not producing live foliage or appearing dead: <20% was recorded as low, 20%-40% medium, and >40% high.

Fruit production was a visual estimate based on the number of flowering/ fruiting spurs. I did this by first categorizing the size of the crown, and then estimating what percentage of the crown was producing fruit or flower clusters. Fruit production used categories: high, medium-high, medium, medium-low, low, and none. Low fruit production was less than five clusters visible, while high fruit production was many clusters on a large crown. The intermediate categories represent trees producing some fruit throughout the crown, and were categorized based on crown size.

Lastly, I recorded whether the tree had been protected by an exclosure and whether the exclosure was new or old. New exclosures refer to those constructed by Laskeek Bay Conservation Society, CHN, and BC Parks in March, 2022.

Young Trees

Young trees were classified as being greater than 30cm in height but less than 5cm diameter at the base (ground level). This size classification was created to exclude mature trees which are generally over 5cm at the base, and seedlings which are generally under 30cm. I chose to record trees within this size classification because previous studies (Vanderstar and Joseph, 2000, as cited in Dickson and Moore, 2021), as well as observations from earlier visits, lead me to believe that they were lacking. Where a young tree was located, tree height was recorded along with any evidence of deer browse.

Regeneration

This was an estimate of the number of seedlings, as well as fresh shoots from rootstock within the plot. This category was based on very young growth, less than 30cm in height and generally not yet woody in structure. Regeneration was estimated and categorized as low, medium, or high rather than counted because regeneration was often a bundle of shoots, and it would be difficult to accurately count each one.

Stumps/ Dead Trees

Stumps and dead trees were counted within the plot. Only stumps and dead trees that could be positively identified as crab apple were counted. Dead crab apple was most easily identifiable by its hard heartwood and its branching structure. I wanted to use this category to compare the current size of the grove to what it may have looked like historically.

4.2 Exclosures

On August 24th and September 9th I constructed 25 exclosures with the help of a volunteer. These exclosures were in addition to the 32 others constructed by Laskeek Bay Conservation Society, BC Parks and CHN staff. Plot surveys (n=10), as well as previous observations, indicated that very few seedlings were surviving to become saplings or young trees. Because of this observation, I focused this part of the project on protecting seedlings and saplings from deer browse.

Large exclosures were built using four metal posts or rebar, and green plastic fencing. Metal posts were pounded into the ground using a post-pounder. The fencing was then wrapped around the perimeter

and attached to the posts using zap straps. The goal for large exclosures was to protect a single mature crab apple from beaver chewing, while also protecting the regeneration along the drip-line and at the roots from deer browse. I selected sites for large exclosures where there was recent beaver sign, where the area had many stumps or beaver felled trees, where the mature tree was healthy (low crown dieback), and where seedlings could be protected within the dripline. Large exclosures varied in size depending on site requirements, but walls were kept less than 8ft in length. Exclosures were kept small because larger exclosures suffer more damage, making them more susceptible to breach and requiring more maintenance (Dickson and Moore, 2021).

For each exclosure, I recorded the latitude and longitude and a description of the exclosure. I also recorded information on the crab apple present within the exclosure, any beaver or deer sign, and additional notes on any other notable species within the exclosure or other relevant information. Photos were taken of each exclosure for future comparisons. All information was added to a spreadsheet created by Laskeek Bay Conservation Society with information on all other exclosure work from 2022.

Small exclosures were four-foot-high cones around seedlings, saplings and small trees. Cones were made out of chicken wire with 3.5-inch X 2-inch squares, and western red cedar stakes that I cut to 1-inch X 1-inch. Cedar stakes were pounded into the ground next to the seedling. The chicken wire was then wrapped into a cone and fastened to itself before sliding over the seedling and attaching to the stake with zap straps. Cones were made to protect the seedling or sapling from deer browse until out of browse height. For monitoring purposes, I recorded the coordinates for each cone, noted whether the crab apple had visible deer browse, measured the height of the plant, and took photos.

I built cones at plot sites 1, 3, 7, and 10. Firstly, these sites were selected because they are close to the boat launch, and have been the focus of recent and historic exclosure construction. My assumption is that this will make monitoring of the seedlings more likely. Secondly, they were chosen because these are some of the larger groves, with many stumps and dead trees, and very little young tree recruitment.

5.0 Results

In total, one hundred and seventy-eight mature crab apple trees were surveyed over ten plots within the study area of Kwiid Suu. The results of these surveys are outlined below. Additionally, four large exclosures and seventeen small exclosures were constructed.

5.1 Beaver Impact

Table 1 – Beaver Chewing (n=178)

None	New	Old	Unsure
76 (**42%**)	40 (**22%**)	77 (**43%**)	7 (**4%**)

Results do not total 100% because some trees had both old and new chewing.

New beaver chewing was present in four of the ten plots; old beaver chewing was present in nine of the ten plots. The northernmost plot had the greatest amount of newly chewed stems. This is outlined in the graph below. Although the objective was not to compare data between plots, but to observe the cumulative data, this graph was included to show that the majority of new chewing came from one site.

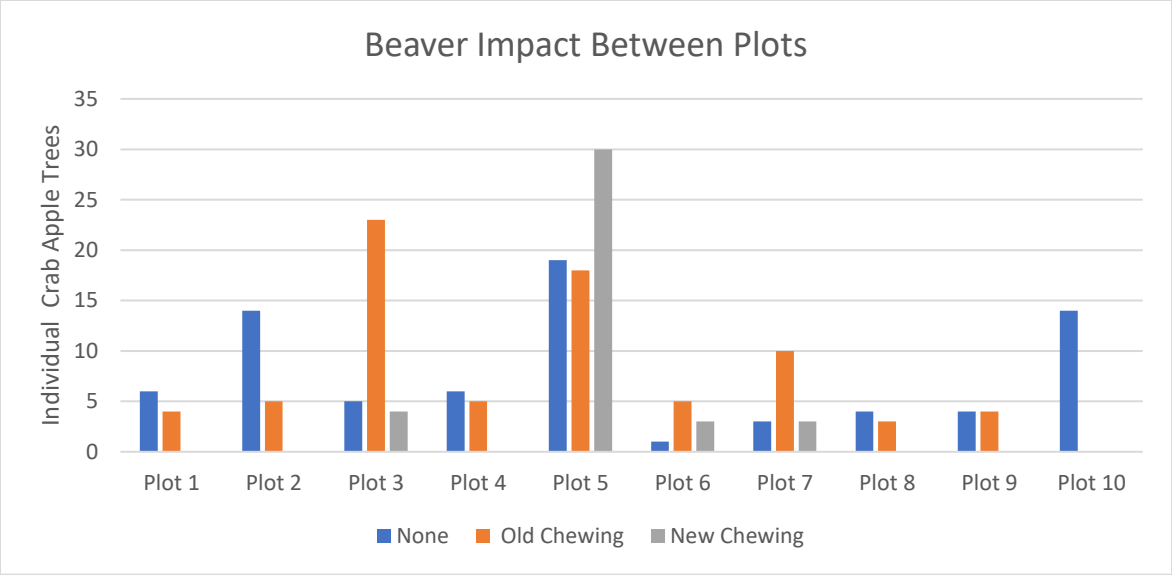

Figure 4 A comparison between plots of beaver impacted crab apple trees

5.2 Crown Dieback and Fruit Production

Crown dieback and fruit production were used as health measures for mature crab apple within the study plots. Crown dieback was low in 58 % of trees surveyed. This indicates good overall health, despite the fact that the majority of mature trees surveyed have experienced old or new beaver chewing. Fruit production was low or nil in 42% of trees surveyed.

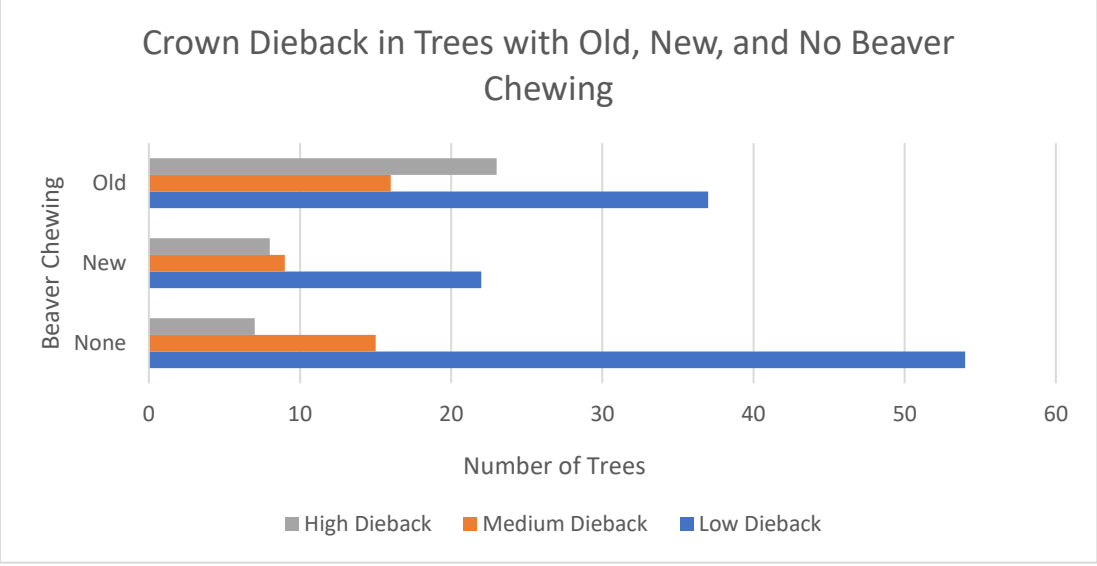

Figure 5 Crown dieback categorized by the presence of beaver chewing

Table 2 - Crab Apple Health Measures (n=178)

Crown Dieback					
Low	Medium	High	N/A		
98 (**58%**)	39 (**21%**)	39 (**21%**)	2 (**1%**)		
Fruit Production					
None	Low	Medium-Low	Medium	Medium-High	High
28 (**16%**)	46 (**26%**)	25 (**14%**)	39 (**22%**)	23 (**13%**)	17 (**9%**)

These results are consistent with observations by Gerry Morigeau (Personal Communication 2022) who says that crab apple fruiting on Haida Gwaii is generally low, with a few trees here and there producing more fruit. Gerry also stated that, some years, warmer spring weather will bring a more abundant crop. Although not part of the survey, I observed fruit production to be most affected by exposure to sunlight, with trees along the shoreline fruiting more heavily than in the understory. Because of natural variation in fruit abundance from year to year, and because of the uncertainty of how beaver chewing will affect fruiting, fruit production may not have been the best choice for a health measure.

5.3 Grove Composition

Regeneration was found to be high in two plots, moderate in five plots, and low in three plots. Young trees, however, were found in only four of the ten plots. Twenty-seven young trees were observed in total, 12 of which were growing out of old exclosures. Another 10 were growing from salal thickets. Twenty-one of the 27 young trees showed evidence of deer browse.

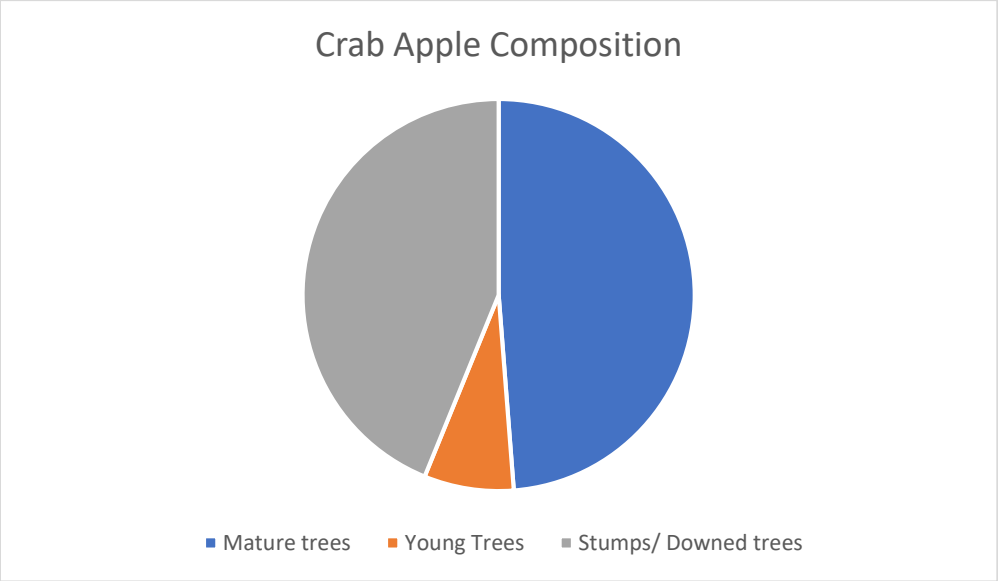

Figure 6 Cumulative composition of young, mature and dead crab apple within all plots

One hundred and sixty stumps and downed trees were counted. It is possible that some of the downed trees were felled though windthrow, or a combination of beaver chewing and wind. Some groves had massive course woody debris accumulation from downed trees, such as grove five, the largest grove

surveyed where 39 stumps and downed trees were found within the 20mX20m plot. It is likely that this dead wood accumulation affects light penetration to seedlings at ground level.

It was beyond my abilities to estimate how old the downed trees were; however, apple is generally regarded as non-resistant to decay. I only counted stumps and stems with heartwood still identifiable as crab apple, which illustrates that this mass die off is relatively new.

5.4 DBH

The average DBH for all mature trees surveyed was 15.1cm. Mature crab apple stems generally range in diameter between 10cm and 30cm (de Echeverria, 2013), with site conditions likely affecting growth rates. I was unable to find an age expectancy for *Malus fusca* or the closely related Asian varieties.

5.5 Exclosures

With the help of a volunteer, I constructed four large exclosures and 17 small exclosures (cones) within the study area. These exclosure were built in addition to the 32 others built by BC Parks, Laskeek Bay Conservation Society, and the CHN, bringing the total number of new exclosures to 53.

Figure 7. A small cone exclosure around a Pacific crab apple seedling (left) and a large exclosure around a mature crab apple and a western redcedar (right).

6.0 Discussion and Recommendations

Exclosures are necessary if Pacific crab apple populations are to be preserved at Kwiid Suu. The surveys completed with this project have illustrated that seedlings need protection from deer browse in addition to protecting mature stems and controlling beaver. With large exclosures, it is possible to protect both regeneration and mature crab apple from both invasive species by including the drip line and root system of the tree within the exclosure. Exclosures that are made too large, however, are at greater risk of being damaged, and require more maintenance (Dickson and Moore, 2021). This was observed at Plot 10, where a large exclosure from 2001 was recently damaged and breached, allowing beaver and deer to decimate many years of growth. Multiple smaller exclosures encompassing this same area would have prevented this to some extent. Chris Ashurst (Personal Communication, 2022) suggested many cells within a larger exclosure, with walls separating each cell from the other. With this method, if one cell is breached the others are still protected.

Growing and planting crab apple seedlings is suggested by Dickson and Moore in their three-year plan (2021). This could be useful in re-establishing groves in areas where few or no crab apple remain. However, in most of the groves I surveyed, regeneration appeared high enough to support recruitment if browsing could be prevented. Stooling from the rootstock of chewed or felled crab apple is often vigorous and should be prioritized for protection with fencing. Cones provide a very low-cost option for protecting seedlings and shoots, and will require much less maintenance than larger exclosures. Cones are especially useful because they can be easily moved to another seedling if the original seedling dies for reasons unrelated to browsing. This method has been used at Kumdis Island to protect crab apple seedlings from deer browse (Gerry Morigeau, personal communications 2022).

Another possible option for crab apple recruitment that avoids growing crabapple from seed is to transplant seedlings from unsuitable areas. Regeneration appeared to be very high below the highwater line, most notably at the gravel beach near grove five, where the low nutrient substrate may be ideal for germinating seedlings. This area, however, is well below the winter high water line, and it appears that no seedlings are surviving. These seedlings could be transplanted to a suitable area with browse protection in the fall.

Figure 8 Crab apple seedlings germinating in the gravel below the winter high water line.

Natural deer barriers also appear to be important for crab apple recruitment, with salal thickets as the most obvious example. At plot two, eight young trees were found growing from salal, the highest of any plot, and a similar group of young trees was observed growing from salal near the trail head. If crab apple planting was to occur at Kwiid Suu, there could be some experimentation with planting seedlings into salal thickets instead of using cones.

As suggested by Dickson and Moore, bi-annual maintenance of the exclosures will be crucial to their longevity. Bi-annual monitoring will also allow for experimentation with various exclosure methods to determine what is most effective. During this project, height was recorded for all seedlings protected by cones. Height can be tracked, as well as evidence of deer browse to determine the effectiveness of cone exclosures. For larger exclosures, photo documentation is a simple way to monitor growth. If resources are available, vegetation surveys of the exclosures could be done.

7.0 Conclusion

Pacific crab apple trees are losing their competitive advantage Kwiid Suu due to the impacts from beaver and deer. The results from the surveys undertaken in this project align with past studies (Vanderstar and Joseph, 2000, as cited in Dickson and Moore, 2021): crab apple groves have been heavily impacted by

beaver chewing, and recruitment of young trees is very sparse. Though far below historical levels, many healthy, mature, fruit bearing crab apple trees have survived at Kwiid Suu and regeneration can be seen in most of the significant groves. However, very few of these seedlings are surviving without protection. Exclosures have been proven effective on Haida Gwaii and should continue to be used in protecting both mature crab apple and crab apple seedlings. It is likely not feasible to achieve all of the recommended actions from this report or previous management plans. In this case, constructing cone exclosures around naturally regenerating seedlings is a low cost and low maintenance option to increase crab apple recruitment and should be prioritized if resources are lacking. Both invasive species have populations too large to successfully eliminate from Haida Gwaii, but through localized control methods, exclosures, and potentially planting and transplanting, it may be possible to preserve the remaining crab apple groves at Kwiid Suu.

8.0 Acknowledgments

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