

**Canada Yew and White-tailed Deer at the Apostle Islands:
Summary of Research to Date with Recommendations for
Continued Monitoring and Management**

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Canada Yew and White-tailed Deer at the Apostle Islands: Summary of Research to Date with Recommendations for Continued Monitoring and Management

Abstract. Reproductive effort and vegetative growth of tagged Canada yew (*Taxus canadensis*) plants have been measured between 1982 and 2000 on several islands that differ in deer browsing history within the Apostle Islands National Lakeshore. The long-term goals of this research are: 1) to determine the relative importance of seedling recruitment and vegetative growth in the expansion of Canada yew in previously browsed populations following the cessation of browsing and 2) to monitor growth and mortality in browsed versus unbrowsed Canada yew populations. The resulting data are used to answer several questions regarding the long-term impact of deer browsing on Canada yew and the growth and “recovery” of Canada yew populations following cessation of browsing. The fundamental conclusion developed in this report and several publications cited in this report, is that Canada yew and white-tailed deer are incompatible at the Apostle Islands. Several management recommendations are presented for Park Service staff to implement to test some of the hypotheses presented in this report and to continue to monitor the long-term impacts of deer on Canada yew. These recommendations include continuing the long-term monitoring of reproductive effort and vegetative growth of Canada yew on islands currently with and without deer.

Introduction

Between 1982 and 2000 I studied the reproductive ecology of Canada yew in relation to browsing by white-tailed deer on several islands of the Apostle Islands National Lakeshore that had experienced different deer browsing histories. Methods included surveys of annual reproductive effort of marked plants conducted over several years (1982 – 2000), an exclosure experiment (1983 – 2000), and a simulated browsing experiment (1983 – 1986). The results of the first phase of this work were published in six papers and a doctoral dissertation.

Beginning in the early 1990s my research entered into a new phase focusing on four populations located on four islands that had different deer histories – two islands had high densities of deer in the past, but on which deer are no longer present (Rocky and Manitou), and two islands on which there has been a continuous deer population since the 1950s (Basswood and Oak). For each of these populations, I recorded male and female strobilus production of tagged plants to determine the impact of chronic deer browsing on Canada yew reproductive effort. In addition, on each island I mapped all yew plants within a plot approximately one hectare in area to begin a long-term study of yew reproductive effort. The goals of this study were 1) to determine the relative importance of seedling recruitment and vegetative growth in the expansion of Canada yew in previously browsed populations following the cessation of browsing and 2) to monitor growth and mortality in browsed versus unbrowsed Canada yew populations. In addition, I continued monitoring the exclosure experiment on Basswood Island where 23 plants have been protected by fences since 1983. I recorded reproductive effort of control and fenced plants in almost every year between 1983 and 2000. During this time period, I was also able to visit and sample plants on Outer Island that had been surveyed in the 1980s; Outer Island has no known history of deer browsing.

The continuation of this monitoring will provide important information on the long-term impact of chronic, low intensity deer browsing on Canada yew sexual and vegetative reproduction. Canada yew has been described as an important component of the understory of unbrowsed northern forests, but has largely been extirpated from much of its range in the northern forests by deer browsing. The Apostle Islands NL provides an opportunity to monitor this plant-herbivore relationship in an experimental and comparative context that may not be possible elsewhere; the Lakeshore provides a range of yew densities on islands that have experienced different deer histories. It is possible that this long-term dataset of deer browsing and reproductive effort for an understory woody plant is unique.

In this report, I briefly summarize the results of the 18 years of quantitative sampling, and present recommendations for managing the deer-yew interaction on the Apostle Islands. An important premise of these recommendations is that maintaining the character of the dense yew understory on islands without deer is a primary management goal of Park Service staff.

This Canada yew-dominated understory, characterized by nearly complete yew understory coverage in some forest types, is not unique; small, isolated patches of Canada yew can be found throughout its range, typically in conditions of very high snow cover or in special topographic situations where accessibility to deer is limited. Nevertheless, throughout its range, most occurrences of Canada yew consist of widely scattered individuals that are too small to be reproductive. It is the spatial extent of the coverage of yew on the Apostle Islands that makes this resource special.

Methods

The basic sampling design for all surveys of reproductive effort was similar, but with slight modifications depending on the specific circumstances of the island population and the questions being asked. This methodology consisted of randomly or systematically selecting yew plants and counting male and female strobilus production and, occasionally seed production in permanently marked yew plants. All plants were tagged and labeled with aluminum tags and the location of the plant was marked with red or blaze orange pin flags. Repeated counts of male and female strobilus were made on these permanently marked plants for varying lengths of time, ranging from 12 to 19 years. Island populations varied in their deer browsing history and yew density.

Data described in this report were collected from Rocky Island (1982-2000), Manitou Island (1989-2000), Basswood Island (1983-2000), and Oak Island (1985-2000), although not all islands were sampled every year. The data were collected to examine variation in reproductive effort and sex expression in yew populations on islands where deer are no longer present (Rocky and Manitou) and yew populations on islands that currently support deer (Basswood and Oak). Yew plants on Rocky and Manitou were systematically located along transects. At 10-meter intervals along each transect the plant closest to the sampling point was tagged and flagged, and male and female strobili were counted on the tagged individual in early May.

On Basswood and Oak Island yew plants were at much lower density. An intensive search located all plants within a bounded area, and these plants were tagged with aluminum tags. Male and female strobilus production was recorded for all of these plants on these two islands in early May. All censuses were made on plants growing in the forest understory to minimize differences in reproductive effort resulting from gross differences in light and mineral resources. I relocated plants each spring in subsequent years and counted male and female strobili for all marked plants. Seed production was not recorded for any plant on Manitou Island and on Rocky, Oak, and Basswood Islands no seed production was recorded after 1986.

Differences in annual plant means in male or female strobilus production and plant size were measured by repeated measures ANOVA (Wilkinson 1996). Data were typically transformed by $\log_{10}(Y+1)$ calculations (where Y = male or female strobilus production) prior to analyses. More details on analyses can be found in Allison 1990a, 1990b, 1990c, 1991, 1992, 1993, as well as in an unpublished report available from the author upon request.

Mapping

All yew plants in predefined areas on Rocky Island in 1992 and on Manitou Island in 1993 were mapped. Two different techniques were used to map plants. On Rocky, a 20m by 20m north-south grid was surveyed with a transit and stadia rod creating multiple 400m² plots. The location of the grid was intended to encompass most of the plants that had been surveyed for studies of long-term reproductive effort (i.e., “line plants” describe earlier). Yew plants in each of the 400m² plots were mapped to the nearest cm; the distance to each plant was measured from two corners of each plot. Twenty-eight plots were mapped encompassing an area of approximately 1.12 hectares. I used the Visual Basic program “Intergrd”, a mapping program created by Emery Boose of the Harvard Forest, to convert the two distance measures into X-Y coordinates (“INTERGRD” is a modified version of “INTERPNT” (Boose et al. 1998).

On Manitou, a one-hectare area was chosen that encompassed plants on four of the seven survey lines. Three reference stakes were established within the hectare area and given arbitrary coordinates, in cm, of (0,0), (9,0), and (9, 12). I used the mapping procedure INTERPNT as described by Boose et al. (1998) to accurately locate plants to within 20 cm.

In 1993 and 1994 on Rocky and 1994 and 1995 on Manitou, male and female strobilus production were recorded for all mapped plants and gender was calculated for each plant using the formula of Lloyd (1980). In 1993 on Manitou and 1994 on Rocky, size of all mapped plants was measured and converted to area as described below.

Plant Size

In late summer 1985 I estimated the size of all plants tagged at that time (n =69) by measuring the length and width of each tagged plant and the plant’s nearest neighbor. The first measurement was in the longest dimension of the plant, and the second measurement was perpendicular to the first measurement. These measurements were used to calculate surface area of each plant based on the formula for an ellipse ($l*w*\pi$).

In spring 1994, I expanded the sample of plant size measurement to include all mapped plants (more than 300), a sample which included the 69 plants first measured in 1985. I compared differences in plant size between 1985 and 1994 for the 69 plants and calculated average annual expansion for each of these plants by dividing the total increase in surface area by the number of growing seasons (nine) between late summer 1985 and spring 1994. This method obviously ignores potential annual variation in expansion rate of individual plants, which could not be calculated from the available data.

In May 2006, I relocated all study populations on Basswood, Manitou, Oak, and Rocky Islands and obtained several GPS coordinates for each population. No systematic recording of strobilus production was made, but I attempted to relocate plants on Basswood and Oak Island, noted condition and checked strobilus production when possible. I also visited Sand Island and York Island conducting a brief assessment of the status of the yew populations on these islands that had recently been colonized by deer.

Results and Discussion

Strobilus Production

Figures 1 and 2 show the changes in male and female strobilus production, respectively, for Rocky, Manitou, Oak, and Basswood Islands between 1982 and 2000. Strobilus production on Rocky has been growing exponentially. Growth in strobilus production on Manitou, which had been increasing, had stalled within the period of measurement after the re-establishment of deer, even though the numbers of deer appear to be low. Strobilus production on Oak and Basswood, islands that have contained low numbers of deer for more than 50 years, remains low, and clearly show no indication of increasing.

Figures 3 and 4 compare changes in male and female strobilus production, respectively, on Basswood fenced and unfenced plants since 1983. The pattern of strobilus production in unfenced, or control, plants is comparable to that observed for the larger yew “population” in the study area. Changes in strobilus production in fenced plants mirrors that observed for unbrowsed plants on Rocky Island. Close examination of male strobilus production of unfenced plants indicates a cyclic pattern of browsing by deer possibly related to variation in snow depth and changes in plant size.

A probable scenario is that plants that survive browsing by deer grow for several years before they reach a size where they become vulnerable to deer browsing. The plants are browsed, heavily, and the cycle is repeated. This scenario is supported by browse history of yews on Basswood and Oak (Table 1) that depict the variation in browse intensity, measured as number of plants browsed in a year. Plants on Basswood Island, for which I have the longest record, were browsed one to three times during the 18-year observation period. Eighteen yew plants died on Basswood between 1983 and 2000, 11 after the heavy browse year of winter 1993-94. By comparison, only two plants have died on Rocky Island during that period; both of these were seedlings that were one to two years old in 1993.

Although no estimates of deer numbers were made for Oak and Basswood, it is likely that the numbers were never very high. The large extent of mature forest and the small area of openings on these two islands does not provide habitat to support large numbers of deer. Neither does the understory otherwise show evidence of heavy browsing by deer. Both islands are also hunted annually and the numbers of deer removed annually rarely exceeded a few animals.

APOSTLE ISLANDS **MALE STROBILUS PRODUCTION** **Deer Present versus Deer Absent**

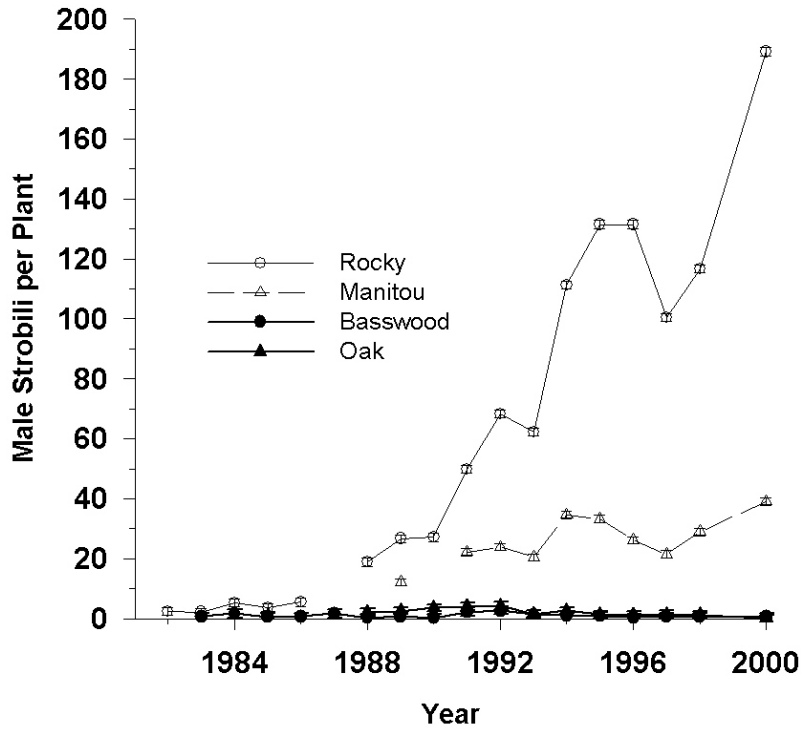


Figure 1. Mean male strobilus production of Canada yew between 1983 and 2000 on Islands with (Rocky and Manitou) and without (Basswood and Oak) deer at the time measurements began. Deer apparently colonized Manitou in the early 1990's. Results are based on log-transformed means of male strobilus production collected from plants as described in the text. Error bars equivalent to one Standard Error are displayed for each year.

APOSTLE ISLANDS
FEMALE STROBILUS PRODUCTION
Deer Present versus Deer Absent

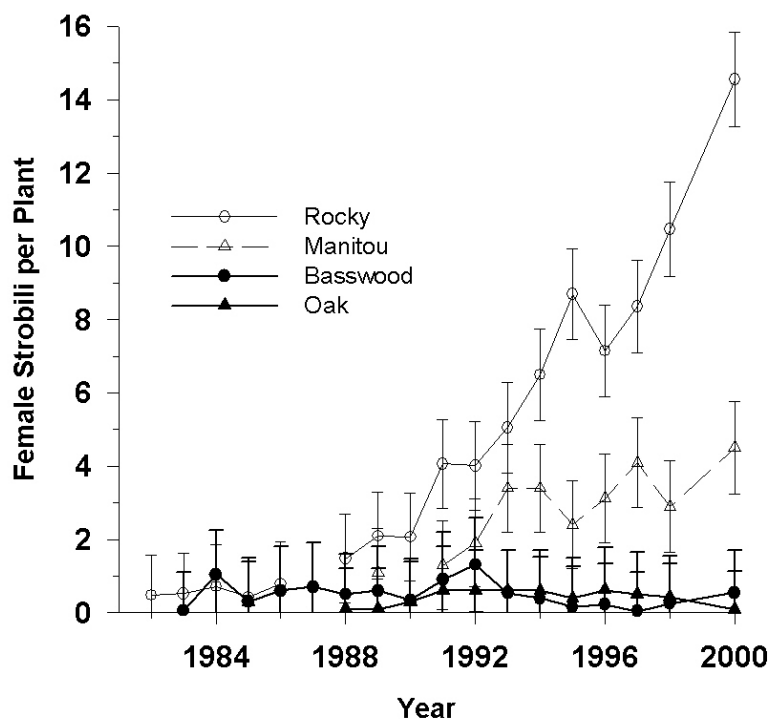


Figure 2. Mean female strobilus production of Canada yew between 1983 and 2000 on Islands with (Rocky and Manitou) and without (Basswood and Oak) deer at the time measurements began. Deer apparently colonized Manitou in the early 1990's. Results are based on log-transformed means of female strobilus production collected from plants as described in the text. Error bars equivalent to one Standard Error are displayed for each year.

BASSWOOD ISLAND EXCLOSURE STUDY

MALE STROBILI

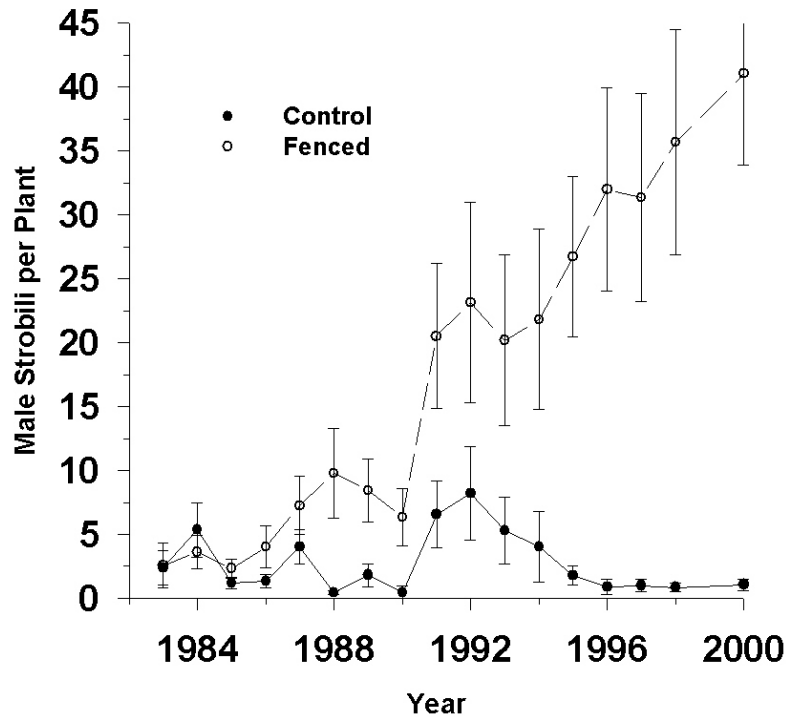


Figure 3. Mean male strobilus production of Canada yew between 1983 and 2000 on Basswood Island for fenced and unfenced plants. Results are based on log-transformed means of male strobilus production collected from plants as described in the text. Error bars equivalent to one Standard Error are displayed for each year. Sample size was 23 plants in each treatment group at the start of the experiment, but has declined due to plant mortality.

BASSWOOD ISLAND EXCLOSURE STUDY

FEMALE STROBILI

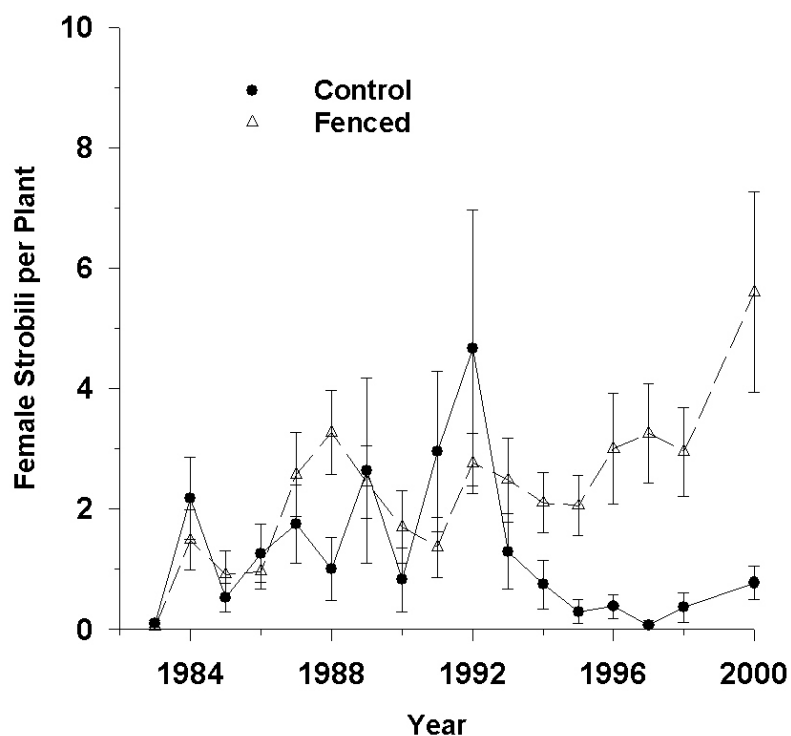


Figure 4. Mean female strobilus production of Canada yew between 1983 and 2000 on Basswood Island for fenced and unfenced plants. Results are based on log-transformed means of male strobilus production collected from plants as described in the text. Error bars equivalent to one Standard Error are displayed for each year. Sample size was 23 plants in each treatment group at the start of the experiment, but has declined due to plant mortality.

Table 1. Percent of plants browsed by year between 1983 and 2000 on Basswood, Oak, and Manitou Islands; absolute number of plants browsed is in parentheses. No attempt was made to separate browsing magnitude, although most plants, when browsed, were browsed heavily. N/A means that the population on that island was not sampled in that year. Note: The number of tagged plants on Basswood increased from approximately 52 to more than 90; on Oak Island this number increased to more than 60 in 1993 from 37 in 1985. Calculation of percent of browsed plants factors in plants that died the previous year. No deer were present on Rocky Island during the period of observation.

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Basswood	36% (27)	6% (3)	12% (6)	0	0	20% (10)	4% (2)	0	0	0	38% (35)	75% (66)	5% (4)	4% (3)	1% (1)	0	N/A	2% (1)
Oak	N/A	N/A	0	N/A	N/A	16% (11)	4% (3)	6% (4)	16% (11)	0	24% (16)	6% (4)	26% (17)	6% (4)	2% (1)	17% (11)	N/A	60% (39)
Manitou	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	2% (1)	0	0	13% (6)	17% (8)	21% (10)	0	0	N/A	32% (15)

Plant Size and Expansion

Not surprisingly, by 1994 the size of the original 69 plants first measured on Rocky Island in 1985 had increased significantly (Table 2a); size was estimated as surface area. Mean surface area of the 69 plants had increased nearly five fold in nine years – the average surface area increased from 0.18 m² to 0.87 m². The average size of a larger pool of plants (300+) containing the 69 described above was 2.1 m² in 1994.

Absolute growth rate, i.e., estimated as cm² increase per year, increased linearly with plant size (Table 2b). Conversely, the rate of increase decreases significantly with plant size (Table 2b); larger plants add more area, but at a lower percentage rate of increase than smaller plants. I do not know if this declining rate levels off eventually, nor do I know whether the positive change in absolute increase levels off or slows, as plants get larger. The answer to both of these questions has implications for estimating the rate of recovery of pre-browse conditions (see below).

Observations of Canada yew – May 15, 2006 visit to the Apostle Islands.

Basswood and Oak Island. Yew plants on these two islands continue to be browsed at periodic intervals effectively keeping plants on these two islands small and in a perpetual, pre-reproductive state. Several tagged plants had died since my last visit in May 2000. I relocated all fenced plants. One exclosure fence had disappeared, and trees, or parts thereof, had fallen on three of the exclosures. Most exclosures on Basswood are still functional; minor work, including adding or replacing stakes and adding fence would considerably extend the life of these exclosures. It is interesting to note that there is little other indication that the deer on these two islands are having any impact on the vegetation. Deer can negatively affect abundance of understory herbs; at least on Basswood this impact is far from obvious.

Manitou Island. Deer browse was first observed here in 1993. Most yew plants have experienced some browsing between 2000, the date of the last visit, and most recent visit in 2006, but it is not clear whether deer are still present on the Island. As the strobilus production results indicate, the interesting observation is that reproductive effort has stopped increasing, unlike the approximately exponential increase observed on Rocky Island.

Sand Island. Deer colonized Sand relatively recently, but the impact of their presence is clear. Browsing impact on Canada yew is most severe near the public dock, where many dead or heavily browsed stems of yew can be found. The “skeletonizing” of yew (where foliage is stripped from the entire branch) observed here is very characteristic of heavy browse episodes of yew observed on the mainland. Browse intensity of Canada yew varies along the trail to the lighthouse. Within the old-growth area, there is at least one large patch of Canada yew to the west of the trail that has sustained no browsing as of May 2006.

Table 2: a) Change in cross-sectional area between 1985 and 1994 of selected Canada yew plants on Rocky Island. Cross-sectional area was calculated as described in the text and is presented as cm^2 ; b) Plant size versus absolute growth and relative growth rate between 1985 and 1994 for selected Canada yew plants on Rocky Island. Absolute growth is presented as mean number of cm^2 per year; relative growth rate is presented as average percentage increase (the total increase divided by the number of years between measurements. Rates use 1985 plant size as the starting point. Differences between plant size and absolute of increase are statistically significant at $p < 0.001$; differences in percentage increase are statistically significant at $p = 0.05$. Test for the latter was based on arc-sin square root transformation of percentages prior to analysis.

a. 1985 versus 1994 Cross-sectional area for selected Rocky Island yews.

Year	1985	1994
Number plants	69	69
Mean (cm^2)	1787.00	8735.96
Standard Error	293.96	1069.77

b. Least Square Means for absolute and relative annual growth rate by plant size in 1985 on Rocky Island between 1985 and 1994. The number in parentheses is the standard error of the mean.

Plant Size	Number of Plants	Growth Rate (% increase)	Absolute Increase (cm^2)
< 1000 cm^2	34	0.24 (0.02)	354.28
1000 – 2500 cm^2	19	0.20 (0.02)	739.76
> 2500 cm^2	15	0.18 (0.02)	1770.29

York Island. Yew in the area of the campground and beach on the north side of the island has sustained heavy browsing. Many dead stems or “skeletonized” stems were present. Further east along the coast and a bit inland I visually estimated that yews there had lost, approximately 50% of the foliage surface area (as distinct from 50% available browse), although yew coverage was still extensive. Little browsing was observed on other woody plants on York. Red-osier dogwood (*Cornus stolonifera*) had sustained moderate browsing. Interestingly, Northern White Cedar (*Thuja canadensis*), which was abundant in open areas on the island, remained unbrowsed, although in many cases, yews immediately adjacent were nearly heavily browsed. Three yew seedlings were recorded in an area near the location of one of the hair sampling stations (see below) in a swampy area near the beach. Very few yew seedlings have been observed over my 20+ years of visits to the Apostle Islands.

Deer population size is being estimated on both of these islands using a “hair capture-recapture method” combined with microsatellite DNA analysis (Julie Van Stappen, personal communication).

Management Recommendations

Six islands of the Apostle Islands National Lakeshore (Eagle, York, Sand, Devils, South Twin, and Outer Islands) “escaped” the expansion of deer onto the Islands from the mainland in the 1940’s and 1950’s. These “deer-less” islands until recently were all characterized by dense, and in some areas, continuous cover of Canada yew in the forest understory. This is a condition that is very rare in the northern forest dominated by northern hardwoods, hemlock, white pine, white spruce, and balsam fir.

Deer ultimately died out on all but two of the Apostle Islands by the 1970’s – Basswood and Oak Islands. Canada yew has been expanding on these islands, and several, e.g., Otter and Cat Islands, are beginning to contain large individuals covering extensive areas. These latter two islands were not as heavily browsed by deer in the 1950’s (e.g., Beals et al. 1960). Recently, however, deer have returned to Manitou (T. Allison, personal observation), and deer are now occurring for the first time in recorded memory on York and Sand Islands (see above).

Maintenance and restoration of the yew-dominated understory has long been a top management priority for the Park Service staff. Achieving this objective could require keeping deer off islands that currently do not have deer and restoring yew density through artificial means. The premises behind these statements are that deer and yew are incompatible, i.e., if deer are present, yew plants are rare, and the rate of expansion of yew via seedling colonization or vegetative growth following removal of deer is so slow as to make reliance on natural recolonization impractical. I address both of these issues below.

Question 1:

a) How long will it take for a yew population to reach coverage in the understory comparable to the coverage prior to colonization by deer?

b) Will the rate of natural expansion and recruitment be acceptable or should Park Service staff actively restore Canada yew populations by planting?

The answer to the question posed in the previous paragraph can be estimated with the growth rate estimates calculated from the 1985 and 1994 data. The assumptions include: a) a linear function adequately and accurately describes the rate of yew expansion between 1985 and 1994 for plants as they grow larger; b) this expansion will continue unchanged indefinitely; c) the mean rate of expansion estimated from 69 plants first selected in 1985 accurately estimates the rate of expansion of all other plants in this population.

In 1994, 324 yew plants occurred in a 1.00 ha area (10,000 m²). In 1994, the area covered by these plants was 682.9 m², or 6.8% of a hectare. Based on the sample of plants first measured for size in 1985, the average rate of increase for this sample of yew plants was 0.077 m² per year [(0.87 – 0.18)/9 years], or 770 cm² per year. Applying this expansion rate, adjusted for plant size (see Table 2b) I estimate that the understory of Rocky Island would have a 50% cover of Canada yew by 2064 or 58 years. Seventy five percent cover would be reached in an additional 40 years. I note that deer have been absent from Rocky for nearly 40 years. Thus, using these growth estimates, the total length of time necessary for Canada yew to reach 75% coverage in the Rocky understory from a starting point near zero is estimated at approximately 140 years.

The previous method uses an absolute amount of increase and also applies this amount to plants that are larger than those recorded in the original dataset. Whether the relationship between absolute growth and plant size continues to change is unknown, i.e., larger plants than I recorded in 1985 and 1994 may have a larger amount of absolute growth. The effect of this would be to reduce the time necessary to reach 75% coverage.

An alternative approach is to use a percentage increase to estimate area covered after a selected number of years when this rate of increase is applied. This method is analogous to calculating the future value of a principal when an annual growth rate is applied over X years. When applying this method, again adjusted for plant size, the amount of time necessary to reach 50% coverage ranges between 15 to 40 years depending on the rate of increase used (5-17%). The latter percentage was the average rate of increase for the larger plants between 1985 and 1994. It is possible that this rate of increase would continue to decrease over time as plants grew larger, but we do not know at what point this rate of increase levels off.

In 1990, I estimated the time necessary for Rocky Island yews to achieve a density (estimated as nearest neighbor distance) comparable to unbrowsed islands was

between 70 and 90 years. Rate of growth was estimated from the average maximum annual growth of single shoots on individual plants (4 cm/year).

Recommendation #1: Remeasure mapped plants on Rocky, Manitou, Basswood and Oak Islands to estimate yew expansion.

Predictions made by the previously described calculations can readily be tested by remeasuring all mapped plants and comparing predicted size with actual size. Expansion rates can be updated to include growth rates for larger plants, possibly increasing the projections of expansion. Remeasuring can be readily done in just a few hours on each island by two to three people and requires measuring the length along the longest axis and the width taken orthogonal to the length measurement. A second, and comparable, measurement on Basswood and Oak would provide additional information on the long-term impact of deer browsing on yew. My observations from the visit this spring indicate that there will be little or no change in plant size on Oak and Basswood.

Following remeasurement, the updated estimates of yew growth could be used by Park Service staff to determine whether augmentation of yew density by planting is needed. Seedling establishment of Canada yew on Rocky appears to be a rare event. I have identified three seedlings (2 years or less in age) within the mapped area. Two of these plants have subsequently died. The third, which is now approximately 15 years old, remains quite small.

Canada yew seeds are notoriously difficult to germinate. A more practical solution to density augmentation is to root yew cuttings. I have had considerable success with this technique. Rooting hormone, a heated greenhouse bench, and an automated misting system are important tools for increasing rooting success. Six to twelve inch cuttings can be rooted in December or January with substantial root growth achieved by spring. Rooted cuttings could be planted the following growing season, i.e., six months after rooting.

Question 2: Are deer and yew compatible, i.e., can Canada yew persist on islands that have deer?

Data collected by Beals in the 1950's and my own field observations over nearly 20 years lead me to conclude (as I did in 1990) that the answer to this question is no. The preference of deer for Canada yew is so great, that deer will browse this species until it becomes rare – Oak and Basswood Islands represent possible and likely outcomes if deer recolonize and persist on an island. Alternatively, we could envision a cycle of colonization, yew depletion, deer extirpation, and yew expansion. This cycle is, however, likely to be asymmetrical. The depletion of yew would take place in a few years after colonization. Deer extirpation may last much longer depending on the quality of the habitat subsequent to yew decline, and as my results suggest, the longest part of the cycle is yew colonization taking more than a century to reach the pre-deer colonization phase. As Manitou indicates, this progress toward the pre-browse state may never be reached if deer recolonize, which seems likely on some islands given the length of time

necessary to reach pre-browse yew coverage. As long as deer populations remain high on the mainland, the islands, particularly those nearshore remain at risk.

As the data on Oak and Basswood attest, a few deer can prevent expansion of yew plants keeping the population to a few small widely scattered individuals. Seed production will be so rare under these circumstances due to pollen limitation (Allison, 1990b, 1990c). Deer recently colonized both Sand and York Islands, and the yew population there has sustained heavy and repeated browsing. If the Park Service wants to keep the yew populations on these islands from declining beyond the current level then deer will need to be extirpated from the islands.

Recommendation #2: Remove deer from York Island.

This island is small enough that a drive of the island has a reasonably high success of taking off all deer. It would be far more difficult to remove deer from Sand Island, but hunting should be allowed to keep the island's deer population low.

Receiving approval for complete removal of deer from an island may be a challenge and providing the information to support this decision is important, to say the least. Much of the data that I have provided along with this report, as well as various publications provide a large measure of support, but collecting additional information specific to Sand and York Island is advisable

Recommendation #3: Continue and expand sampling of yew reproductive effort on islands with and without deer.

The method for sampling should be modified to allow direct comparison of yew reproductive effort, measured as strobilus production. Specifically, I recommend counting male and female strobilus production on randomly selected 30-cm portions of branches on randomly selected plants. The populations sampled should include those on York, Sand, and Rocky, and Manitou, as well as expanding the sample to islands where deer currently do not inhabit. I recommend Outer and Raspberry, and including Devils Island as an additional option. Sample size should be a minimum of 20 plants and five branches per plant, and sampling should be conducted in early May.

An additional impact of deer browsing is reduction in pollination efficiency and this impact can be readily assessed by revisiting the tagged plants described in the previous paragraph in mid to late-June. There is a high correlation between pollen production and pollination efficiency, and a high correlation between pollination efficiency and seed production.

Collecting the data will be limited largely by time necessary to travel from island to island. I estimate the minimum time as one-half person days per island not including travel, i.e., two people could probably complete and island in 2-3 hours, which might enable two islands to be sampled per day. All sampling might be completed in one week.

I would recommend that this be done next May. A decision to repeat this measurement annually or biannually can be made after initial analysis.

Recommendation #4: Resample strobilus production on Oak and Basswood Islands periodically and refurbish exclosures on Basswood.

Results to date from these two islands substantiate the long-term impact of deer browsing on yew reproductive effort and growth. Implementing this recommendation becomes a matter of availability of time and financial resources, especially if Recommendation #3 is implemented. Assessing deer impact on Canada yew populations that have had continuous populations of deer does provide a lower baseline for measuring deer impact and the “recovery” of yew reproductive effort on other islands where deer are no longer present. Sampling strobilus production could be done biannually, and would consist of counting the entire plant for unfenced and mapped plants (versus 30 cm branch segments). A challenge for these two islands is accessibility. The Oak Island population is a 45-minute walk from the dock or sandspit. The Basswood population can be reached easily if wind and wave conditions are suitable at the northeast rock landing; otherwise, a hike of approximately 50 minutes from the Basswood Island dock is required.

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