

ANNUAL TECHNICAL REPORT

**Tree-ring Reconstruction of Historic Insect Outbreaks
Lake Clark National Park and Preserve**

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Abstract

Tree-ring data have been widely used in temperate and high-latitude forested ecosystems to address issues of past disturbance (insects, fire) and long-term climate variability. Regional warming is thought to have triggered the recent spruce bark beetle outbreaks on the Kenai and Alaska Peninsulas. Beetle kill has affected coastal forests extending from north of Lake Clark National Park and Preserve (NPP) south to Tuxedni Bay, as well as stands in Lake Clark Pass and surrounding Lake Clark. As part of this multi-year project, we are using tree-ring records to determine whether bark beetle outbreaks occurred historically in Lake Clark NPP. The objectives of the project are to 1) reconstruct historic patterns of insect outbreaks in forests of Lake Clark NPP; and 2) evaluate the relationship between insect outbreaks and regional climate using existing tree-ring chronologies and long-term climate data. We collected cores from live and dead trees in July 2005 from seven sites in Lake Clark NPP and two sites in Pedro Bay. Current spruce bark beetle activity and/or damage was evident at the Tlikakila River, Currant Creek, Chinitna Bay and Pedro Bay sites. Damage from another, unidentified bark engraver beetle was evident on dead standing and downed trees at the Two Lakes, Telaquana Lake, and Lachbuna Lake sites. To date, we have mounted and sanded tree cores from all nine sites. We have visually counted tree rings and recorded growth changes potentially due to beetle activity and other sources of damage from three of the nine sites (Lachbuna Lake, Telaquana Lake – Braden Cabin, and Two Lakes). The oldest cores processed to date are from Two Lakes and show live tree ages that range from the early 1600s through the 1900s. Visual inspection of cores from the three sites that have been processed show multiple suppression periods since the mid 1800s. These patterns suggest evidence for insect activity at multiple time periods from the mid 1800s to present, although the exact dates, magnitude of growth changes, and synchronicity of patterns will be examined in the next phase of the project, during 2006. The results of this project will provide both baseline conditions and a historic context for long-term monitoring of forested ecosystems in the Park.

Executive Summary

Tree-ring studies have been used to gain information regarding past disturbance (insect outbreaks, fire) and long-term climate variability in temperate and high-latitude forests. In southwest Alaska, a gradual warming since the 1940s is thought to be responsible for the recent spruce bark beetle outbreaks that have killed over 532,000 ha (1.3 million acres) of spruce forest on the Kenai and Alaska Peninsulas. Forests near Tyonek, east of Lake Clark NPP, experienced substantial beetle kill in the 1970s, with the outbreak entering the Park in the 1990s. The objectives of this project are to reconstruct historic patterns of insect outbreaks in forests of Lake Clark NPP and to evaluate the relationship between the timing of insect outbreaks and regional climate (temperature).

Tree-ring data are being used to reconstruct spruce bark beetle outbreaks in the Lake Clark region over the past 200-300 years. Variation in tree-ring widths indicate growth pulses caused by thinning of the forest by beetle kill. This method is based on the assumption that spruce bark beetles kill the larger trees, leaving behind the smaller pole-sized trees. When the smaller trees are released from competition (hereafter referred to as a “release”), they grow rapidly for 60 to 80 years until the canopy closes again and competition for light slows their growth. In 2005, we collected 814 tree cores from live and dead trees from seven sites in Lake Clark NPP, and from two sites on Pedro Bay Native Corporation and Native Council land adjacent to Lake Iliamna. The sites in Lake Clark NPP included stands in the following areas: Two Lakes, Telaquana Lake (two sites), Lachbuna Lake, Tlikakila River-Lake Clark, Currant Creek, and Chinitna Bay. A stand at Polly Creek, approximately 56 km (35 miles) north of Chinitna Bay, was sampled by Ed Berg in 2000 and will also be included in this study.

Current spruce bark beetle activity and/or damage was evident at the Tlikakila River, Currant Creek, Chinitna Bay and Pedro Bay sites. Damage from another, unidentified bark engraver beetle (*Ips* sp.) was evident on dead standing and downed trees at the Two Lakes, Telaquana Lake, and Lachbuna Lake sites. We made only one collection of *Ips*, and it turned out to be in poor condition. Interior stands in Lake Clark NPP currently showed only low, background levels of bark beetle occurrence, and growth rates appeared to be very low, perhaps due to drought stress. Although these interior stands may not have been subject to widespread beetle attack historically, data from Polly Creek, sampled in 2000, indicated a strong release due to beetle kill in the 1870s-1880s.

To date, we have mounted and sanded tree cores from all nine sites. We have visually counted tree rings and recorded growth changes potentially due to beetle activity and other sources of damage from three of the nine sites (Lachbuna Lake, Telaquana Lake – Braden Cabin, and Two Lakes). The oldest cores processed to date were from Two Lakes and showed live tree ages that ranged from the early 1600s through the 1900s with the majority of tree ages in the early 1800s. The oldest cores from live trees processed from Lachbuna Lake and Telaquana Lake dated from the early 1700s. Visual inspection of cores from the three sites that have been processed showed multiple suppression periods since the mid 1800s. These patterns suggested evidence for insect activity at multiple time periods from the mid 1800s to present, although the exact dates, magnitude of growth changes, and synchronicity of patterns will be examined in the next phase of the project, in 2006.

Work in 2006 will include: (1) continued processing of samples (counting tree rings); (2) measurement of tree-ring widths and cross dating of cores; (3) input of tree data into Excel spreadsheets and into format for Dendro software programs; (4) time-series analysis (COFECHA, JOLTS); and (5) initiation of comparison of disturbance chronologies with climate chronologies.

The results of this study will provide baseline information on current forest conditions and will help to define the range of natural variability in insect outbreaks. In addition, we hope to examine the relationship between insect outbreaks and past changes in climate. Sites that show little evidence of past beetle disturbance may provide information about the conditions that inhibit outbreaks, whereas sites that have already been infested may provide clues about the susceptibility of other unimpacted stands. Finally, this work will provide insight into how future environmental changes may influence forest productivity in this region, and will provide a context for forest trends observed during NPS vital signs monitoring.

Introduction

The spruce bark beetle (*Dendroctonus rufipennis*) is the most important agent of mortality in North American high latitude forests (Ford 1986). More than 485,600 ha (1.2 million acres) of spruce forest on the western Kenai Peninsula (Berg 1998; Fastie et al. 2000), and nearly 47,000 ha (116,000 acres) on the Alaska Peninsula (Wittwer 2004) have been killed during the current spruce beetle outbreak that started in the early 1990s. Approximately 37,800 ha (93,400 acres; 23% of forested area) of forest have been affected by spruce bark beetle in Lake Clark NPP. On the western Kenai, mature white spruce (*Picea glauca*), Sitka spruce (*P. sitchensis*) forests and Lutz spruce (a white-Sitka spruce hybrid, *Picea X Lutzii*) have been impacted. In Lake Clark, most of the damage has been to white spruce (e.g., Lake Clark Pass/Tlikakila River; Crescent River).

A recent tree-ring reconstruction of summer temperatures (1769-present) in Lake Clark NPP indicated a general warming in the region starting in the 1940s, and an accelerated warming since the 1970s (Driscoll et al. 2005). With the exception of the Stony River-Lime Hills area in the northwestern region of the Park, fire is not thought to have played a large role in these ecosystems in the past. However, the implications of increased warming are uncertain, and both insect outbreaks and fire have the potential to be strongly influenced by climate (Mattson and Haack 1987; Swetnam and Betancourt 1998; Ryerson et al. 2003). On the Kenai, tree-ring studies indicated that forests experienced regional episodes of thinning in the 1820s, 1880s, 1910s and in the 1970s (Berg 1998, 2000). However, none of these outbreaks were as severe as the 1990s outbreak, which has killed most large white and Sitka/Lutz spruce in the area (Berg 2000).

In spite of widespread spruce bark beetle activity on the western side of the Kenai Peninsula and the current outbreaks on the Alaska Peninsula, we know little about the historic occurrence or frequency of insect disturbance in Southwest Alaska Network (SWAN) Parks. This study will address the following questions relevant to Lake Clark NPP:

- Is there evidence of previous spruce bark beetle outbreaks in Lake Clark NPP?
- When, and at what frequency?
- Where in the landscape? How old are the stands?
- Are the outbreaks localized or synchronized across the landscape?
- Is there a relationship between climate and insect disturbance?

The specific research objectives of this project are as follows:

- 1) To reconstruct historic frequency and occurrence of spruce bark beetle outbreaks in Lake Clark NPP.
- 2) To evaluate the potential relationship between spruce bark beetle outbreaks and climatic variability in the region using existing climate chronologies from Lake Clark NPP and long-term climate data sets from the region.

Methods

We collected tree cores in July 2005 from seven sites in Lake Clark NPP, and two sites on Pedro Bay Native Corporation and Native Council land, adjacent to Lake Iliamna (Fig. 1). The sites in Lake Clark included stands in the following areas: 1) northeast of Two Lakes; 2) south of Telaquana Lake near the Straty cabin; 3) north of Telaquana Lake near the Braden cabin; 4) northeast of Lachbuna Lake; 5) west of the mouth of the Tlikakila River, at the north end of Lake Clark; 6) south of the mouth of Currant Creek; and 7) west of the Ranger's Cabin at Chinitna Bay. We used standard methods (Table 1; Fritts 1976, Cook et al. 1990, Berg 1998) to collect 65-121 cores per stand from both live and dead trees. Coring was conducted in relatively homogeneous, mature, closed-canopy stands of white spruce (*Picea glauca*), below tree-line and away from areas of obvious disturbance. Sites were chosen based on the location and extent of current spruce bark beetle infestation, and the location of previous sampling efforts (e.g., Driscoll et al. 2005), if applicable. Such sites were chosen to avoid errors in interpretation due to windthrow, fire, or normal gap dynamics. Trees were cored at a minimum distance of 10 m (33 feet) from one another and at a height of 100-120 cm (approx. 39-47 inches) (Fig. 2).

Our sites were subjectively chosen for three purposes: (1) to represent a range of sites across forested areas in Lake Clark NPP; (2) to represent a range of sites that have been affected by the current spruce bark beetle outbreak (from low to severely affected stands); and (3) to meet specific criteria (primarily high stand density, composition and age) under which we could reconstruct past beetle history using dendrochronological methods. Each site ranged in size from approximately 10 to 50 ha (25 to 124 acres), depending on local conditions. The sites represent a single forest stand (i.e., uniform density, composition and age), although some were connected to, or near, other stands of similar age and composition.

We do not plan to interpolate information from one stand to adjacent stands or across the broader forested regions of the Park, which would require a geostatistical approach. We do, however, expect to be able to infer whether there were periods of beetle activity historically that were widespread, affecting the multiple stands that were sampled. Our inferences will thus be limited to individual stand conditions, as interpreted within a regional context.

We recorded information on stand structure (e.g., tree size and height, stand characteristics), site characteristics (e.g., elevation, soil characteristics), and disturbance history (e.g., fire history, windstorm/blowdown) for each site. Sampling for determination of historic fire reconstructions was performed opportunistically as charcoal and/or fire-scarred trees were encountered. We collected 17 bark beetle specimens (Family Scolytidae) from five locations, including the Tlikakila-Lake Clark site, Currant Creek, Chinitna Bay, and Pedro Bay. Specimen information is included in Appendix 1.

To date, we have mounted and sanded tree cores from all nine sites. We have visually counted tree rings and recorded growth changes potentially due to beetle activity and other sources of damage from three of the nine sites (Lachbuna Lake, Telaquana Lake – Braden Cabin, and Two Lakes). We expect to begin measuring ring widths in February, 2006 using standard dendrochronological procedures (Stokes and Smiley 1968, Fritts 1976, Cook et al. 1990). The ring-width measurements are essential for relating inter-annual variation in tree growth (i.e.,

releases and suppressions) to insect activity and climate variability. Ring-width series will be run through COFECHA (Holmes et al. 1986), cross-dated, and growth releases will be analyzed as outlined below (see Work Planned for 2006).

Results and Discussion – Work Completed in 2005

Preliminary results by site

An increase of 2 °C (3.6 °F) in mean annual temperature over the last 50 years, and a decrease in mean annual precipitation, have resulted in divergent growth responses by trees in Lake Clark NPP (Driscoll et al. 2005). Stands at Fishtrap and Portage Lakes have showed a decline in growth since the 1970s, whereas those at Twin Lakes and Telaquana have showed a positive response to increasing temperature (Driscoll et al. 2005).

At several sites (Two Lakes, Telaquana, Lachbuna), we found dead and damaged trees heavily infested by an unidentified species of engraver beetle (*Ips* sp.). Spruce bark beetle (*Dendroctonus rufipennis*) levels were low at these sites. The native engraver beetle, *Ips perturbatus*, generally breeds in slash, broken, fallen, or dying conifers and has not been considered a problem. However, there has been a marked increase in the number of trees killed by *I. perturbatus* in Alaska in recent years. Infestations in interior and south-central Alaska have increased by more than four-fold since 2003, primarily along floodplains and in areas disturbed by erosion, harvest, or windthrow (Wittwer 2004). The apparent increase in activity may have been associated with increased spruce beetle-induced mortality, increased forest management activities, and/or increased mean annual temperature. The nearest documented *I. perturbatus* damage to Lake Clark NPP is in the Lower Stony River/Bonanza Hills region, to the west of the Park (Wittwer 2004).

The remaining sites (Tlikakila River, Currant Creek, Chinitna Bay, Pedro Bay, Pile Bay) showed varying levels of *Dendroctonus* damage. The sites at Pedro and Pile Bays were heavily impacted, whereas the other sites showed damage closer to background levels. Of note was the *Dendroctonus* damage in Sitka spruce at Chinitna Bay. An outbreak on the south side of Kachemak Bay has resulted in >90% mortality of old growth Sitka spruce (*E. Berg, personal communication*), whereas the outbreak at Tuxedni Bay in the early 1990s resulted in almost 100% mortality of mature white spruce along the coast and inland.

Beetle outbreaks in the Tlikakila are documented from the 1950s and 1980s (Holsten 1993), but did not lead to stand conversion because many small spruce were left standing. *Dendroctonus* activity remained low in the area until 1991-1992, when the most recent outbreak started (e.g., Fig. 3). Heavy defoliation due to spruce budworm (*Choristoneura* sp.) was also observed in the lower Tlikakila at this time (Holsten 1993), raising concern that the trees weakened by the budworm might then become susceptible to the spruce bark beetle. Trees near the outlet of the Tlikakila River, where we sampled, showed little or no spruce beetle activity in 1993 (Holsten 1993), and light activity in 2005. Holsten (1993) indicated that this stand was at high risk for increased spruce beetle activity. Winds off of Lake Clark may be slowing the movement of beetles downstream, from areas of almost complete mortality 10s to 100s of km away, to areas of

light damage at the outlet. No beetle activity was reported in Currant Creek in 1993 (Holsten 1993).

The outbreak at Pedro Bay began in 1990 and peaked in 1996, and has since declined because most of the mature trees have been killed. Unlike the dead trees on the Kenai, these trees showed little evidence of red belt fungus (*Fomitopsis pinicola*), which indicates that the sapwood has not yet decayed.

We saw no obvious severe stand-wide patterns of growth releases in our tree cores in the field, suggesting that if bark beetles have been present in these stands in the past, the attacks would have been at lower intensity. Many individual trees at the three sites visually analyzed thus far show synchronous suppression and release periods from the mid 1800s to present suggesting light to moderate insect activity was historically prevalent in Lake Clark NPP. However, the exact dates and magnitude of growth changes will be examined in the next phase of the project in 2006. On the southern Kenai, visible growth releases date to the 1870-80s and 1970s, with more subtle growth releases occurring in the 1760s, 1810-20s, and 1910-20s. Although it is entirely possible that spruce bark beetles have not severely impacted the Lake Clark NPP stands in the past, further analysis will be required to determine if, and when, past outbreaks occurred.

A brief description of each site sampled in 2005 is listed below.

Two Lakes – Minor spruce beetle damage and measurable spruce engraver (*Ips* sp.) damage was currently evident at the site. Estimated tree mortality was low. The oldest live cores processed to date are from Two Lakes and show tree ages that range from the early 1600s through the 1900s with the majority of tree ages in the early 1800s. An old avalanche path and debris fan at the eastern margin of the stand appeared to support a younger cohort of trees. Approximately 30% of the live tree cores processed at Two Lakes show a release in tree-ring growth that begins in the 1910-20s. Two Lakes also shows a suppression of growth that begins in the 1880s-1890s in approximately the same percentage of cores. These patterns suggest evidence of spruce beetle activity in the 1910-20s and possibly evidence of damage in the 1880s-1890s by other insects such as the spruce engraver or spruce budworm.

Telaquana Lake – Braden Cabin – We found little evidence of insect damage at the site. Estimated tree mortality was low. The stand was relatively young (most tree ages date from the mid-1800s) at its upslope margin, but appeared to increase in age as we moved down slope. The oldest live cores from Telaquana Lake date from the early 1700s. Many of the larger trees appeared to have established under high light (open canopy) conditions. A few small burn poles were found at the eastern periphery of the stand. Visual inspection of live tree cores ($n = 53$ cores) indicates a series of suppression and release periods from the mid 1800s to present. There appears to be a mild suppression period beginning in the 1860s (~12% of the live trees) followed by a release in growth of many trees in the 1870s (~13% of the live trees). A more recent suppression period also begins in the 1900s-1910s (~30% live trees) followed by a release in the 1920s-1940s (~35% live trees). However, suppressions in growth also occur in many trees (~35% live trees) during the 1930s to 1950s. These patterns suggest evidence for insect activity at multiple times from the mid 1800s to present, although the exact dates and magnitude of growth changes will be examined in the next phase of the project (2006).

Telaquana Lake – Straty Cabin - We found little evidence of insect damage, but a few trees were observed with spruce engraver (*Ips* sp.) damage. Estimated tree mortality was very low. The stand was relatively young (estimate of 200 years) and relatively even-aged. An old debris flow appeared to support a younger cohort of trees. Many of the larger trees appeared to have established under high light (open canopy) conditions.

Lachbuna Lake – We found measurable spruce engraver (*Ips* sp.) damage at the site. Estimated tree mortality was low. The oldest live cores processed from Lachbuna Lake date from the mid 1700s and most trees date from the mid 1800s ($n = 49$ live cores). Very mild suppressions began in the 1860s, 1930s and 1960s. No major releases have been detected. Many individual trees show release patterns in growth but exact dates need to be further examined for synchronicity.

Tlikakila River – We found light spruce beetle damage but no measurable engraver damage. Several large trees had the red needles characteristic of bark beetle damage and appeared to be dying or recently dead (Fig. 3). Estimated tree mortality was low. Four beetle specimens (one specimen of *Polygraphus rufipennis* and three of *Dendroctonus rufipennis*) were collected in the vicinity (Appendix 1).

Currant Creek – We found light to moderate spruce beetle damage and engraver damage. A few large trees had the red needles characteristic of bark beetle damage and appeared to be dying or recently dead. Estimated tree mortality was low to moderate.

Chinitna Bay – We found light spruce beetle damage on Sitka spruce. A few large trees had the red needles characteristic of bark beetle damage and appeared to be dying or recently dead. Estimated tree mortality was low.

Pedro Bay – We found heavy spruce beetle damage. Most of the large trees had the red needles characteristic of bark beetle damage and appeared to be dying or recently dead (estimate of 0 to 5 years). Estimated mortality of mature trees was high.

Pile Bay – We found heavy spruce beetle damage. Most of the large trees had the red needles characteristic of bark beetle damage and appeared to be dying or recently dead (estimate of 0 to 5 years). Estimated mortality of mature trees was moderate to high.

Analyses Planned for 2006

Tasks to be completed during 2006 include the following:

1. Continue processing samples (counting tree rings)
2. Measure tree-ring widths and cross-date cores
3. Input tree age and lab processing notes into Excel spreadsheets
4. Input ring-width chronologies into format for Dendro software programs
5. Begin data review and time-series analysis (COFECHA, JOLTS) for objective 1 (below)
6. Begin comparison of disturbance chronologies with climate chronologies and existing 20th century climate data for objective 2 (below)

Objective 1 –Insect Outbreak Frequency and Regional Occurrence

For each site, we will summarize growth releases detected by JOLTS that show the release history of each sampled tree (cf. Berg and Henry 2003). These release patterns will be compared with historical records and with USDA Forest Service annual aerial surveys of insect activity and other sources of forest disturbance.

Objective 2 –Influence of Climate Variability on Insect Outbreaks

Local and regional climate records will be used to cross-date live and dead trees and to determine the relationships between climate variation and historic insect outbreak periods. If possible, a series of regional climatic records will be created by averaging monthly standard deviations for each instrumented site. Using normalized standard deviations, each station, independent of its particular value of temperature and precipitation, will have the same weight in the averaged regional record (cf. Villalba et al. 1994).

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Table 1. Tree core samples, Lake Clark National Park and Preserve and Pedro Bay Native Corporation sites, 2005.

Site	Location ¹	Dominant Species	Total No. Cores Collected ²
Two Lakes	61.136 Lat, 153.733 Long	<i>Picea glauca</i>	88
Telaquana Lake – Straty Cabin	60.942 Lat, 153.779 Long	<i>Picea glauca</i>	121
Telaquana Lake – Braden Cabin	60.975 Lat, 153.881 Long	<i>Picea glauca</i>	65
Lachbuna Lake	60.495 Lat, 154.006 Long	<i>Picea glauca</i>	65
Tlikakila River – Lake Clark	60.394 Lat, 153.843 Long	<i>Picea glauca</i>	85
Currant Creek	60.304 Lat, 154.008 Long	<i>Picea glauca</i>	80
Chinitna Bay	59.870 Lat, 153.090 Long	<i>Picea sitchensis</i>	121
Pile Bay	59.789 Lat, 153.992 Long	<i>Picea glauca</i>	94
Pedro Bay	59.807 Lat, 154.126 Long	<i>Picea glauca</i>	95

¹ Latitude/Longitude Data: Coordinates derived from Garmin 12 XL GPS. Data has not been differentially corrected. All positions are in decimal degrees and NAD83 datum.

² Multiple cores from a few individual trees are included in this total number.

Figure 1. Sampling site locations (2005).

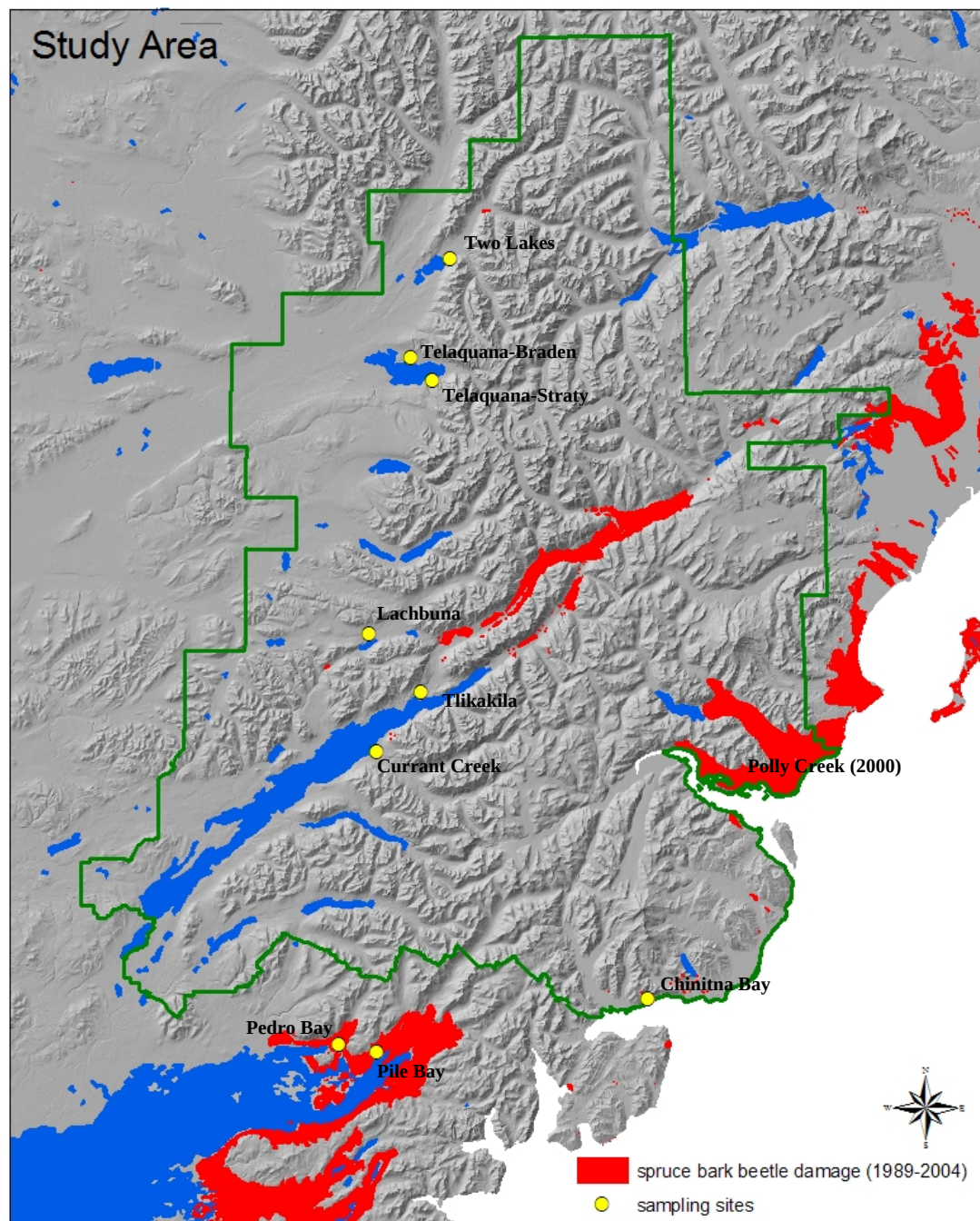


Figure 2. Coring Sitka spruce (*Picea sitchensis*) at Chinitna Bay, Lake Clark NPP.



Figure 3. Spruce bark beetle-induced mortality, lower Tlikakila River, Lake Clark NPP.



Appendix 1. Scolytidae determinations

Vial 1. Alaska. Lake Clark N.P. Tlikakila R. near Lake Clark on downed spruce log. 13 July 2005. M.L. Bowser. UTM 0453942 E, 66957744 N

Accession no. LAKE CLARK NPP-00194

Catalog no. LAKE CLARK NPP 4508 – *Polygraphus rufipennis* (Kirby)

Vial 2. Alaska. Iliamna Lake on beach E of Pedro Bay. 15 July 2005. R Sherriff. UTM 0444357 E, 6628079 N

Accession no. LAKE CLARK NPP-00194

Catalog no. LAKE CLARK NPP 4509 – *Dendroctonus rufipennis* (Kirby), female

Vial 3. Alaska. Lake Clark N.P. W of Tlikakila R. off of Lake Clark. Under bark of dead standing *Picea glauca*. 13 July 2005. ML Bowser, EE Berg, R Sherriff, A Miller. UTM 0453942 E, 66957744 N

Accession no. LAKE CLARK NPP-00194

Catalog no. LAKE CLARK NPP 4510 – *Dendroctonus rufipennis* (Kirby), very callow

Catalog no. LAKE CLARK NPP 4511 – *Dendroctonus rufipennis* (Kirby), very callow

Catalog no. LAKE CLARK NPP 4512 – *Dendroctonus rufipennis* (Kirby), very callow

Vial 4. Alaska. Chinitna Bay under bark of dead standing Sitka spruce on N side of bay. 18 July 2005. ML Bowser. UTM 0494317 E, 6636933 N

Accession no. LAKE CLARK NPP-00194

Catalog no. LAKE CLARK NPP 4513 – *Dendroctonus rufipennis* (Kirby), male, broken

Vial 5. Alaska. Pedro Bay (GPS data). Under bark of *Picea glauca*. 17 July 2005. ML Bowser. UTM 0436933 E, 6630551 N

Accession no. LAKE CLARK NPP-00194

Catalog no. LAKE CLARK NPP 4514 – *Ips* sp. (Kirby), broken head

Catalog no. LAKE CLARK NPP 4515 – *Dendroctonus rufipennis* (Kirby), male

Catalog no. LAKE CLARK NPP 4516 – *Dendroctonus rufipennis* (Kirby), male

Catalog no. LAKE CLARK NPP 4517 – *Dendroctonus rufipennis* (Kirby), male

Catalog no. LAKE CLARK NPP 4518 – *Dendroctonus rufipennis* (Kirby), male

Catalog no. LAKE CLARK NPP 4519 – *Dendroctonus rufipennis* (Kirby), female

Catalog no. LAKE CLARK NPP 4520 – *Dendroctonus rufipennis* (Kirby), female

Catalog no. LAKE CLARK NPP 4521 – *Dendroctonus rufipennis* (Kirby), female

Catalog no. LAKE CLARK NPP 4522 – *Dendroctonus rufipennis* (Kirby), female

Catalog no. LAKE CLARK NPP 4523 – *Dendroctonus rufipennis* (Kirby), female

Catalog no. LAKE CLARK NPP 4524 – *Dendroctonus rufipennis* (Kirby), female

Determinations by Malcolm Furniss, Consulting Forest Entomologist, 1825 Orchard Ave., Moscow, ID; October 7, 2005.