YAKUTAT FORELANDS FOREST HEALTH ASSESSMENT

By Mark Schultz and Tom Heutte

INTRODUCTION

Blowdown of Sitka spruce occurred on 3,500 acres in the winter of 1981 on the Yakutat Forelands (figure 1, Eglitis, 1988). The following summer 3% of the downed Sitka spruce were attacked by spruce beetle, *Dendroctonus rufipennis* (Kby.), (pitch-out, strip, and successful attacks). Two years after the blowdown, 19% of the downed Sitka spruce had successful spruce beetle attacks but brood production was low. Standing spruce were successfully attacked and killed four years after the blowdown event. Within residual stands, outside of the clear-cut units, 815 standing trees were examined in variable prism plots. Approximately 17 percent of the Sitka spruce were dead. Eglitis (1989) then established 20 fifth-acre permanent plots in 1988 to monitor beetle-caused tree mortality. 22% of the spruce had died, most between 1983 and 1985. It was predicted that the infestation would not expand. Between 1988 and 1991 1% of the residual spruce were newly attacked and killed by spruce beetle (Mask, 1992), another 8% were windthrown.

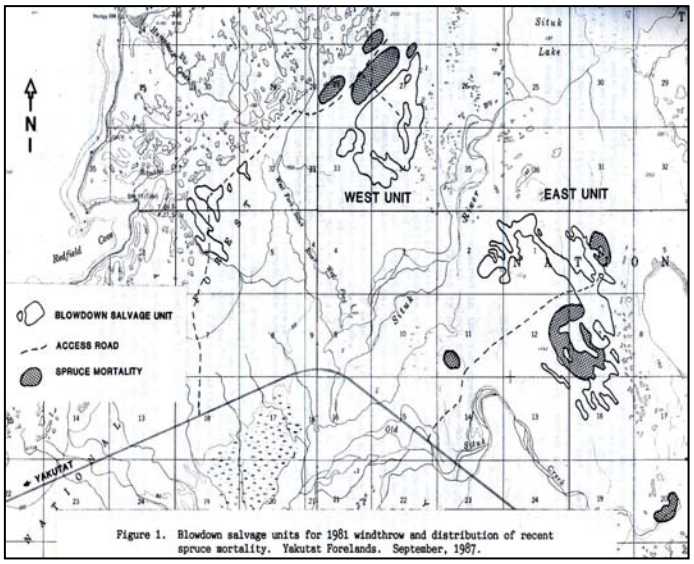


Figure 1. Blowdown salvage units for 1981 windthrow and distribution of recent spruce mortality. Yakutat Forelands. September, 1987.

There was another major windthrow event in November, 2001. Two aerial estimates of the affected acreage were made (Forest Health Protection and Timber Management) (Fig 2). Windthrown trees were examined during August, 2002 for the presence of bark and ambrosia beetles. Areas inspected were along the westgate and eastgate roads, and mile 19. Older trees (> 2 years), knocked down during road contruction, had spruce beetle galleries.

An attempt was made in August of 2003 to re-establish the 20 fifth-acre plots established in 1988. Additional tree harvesting since 1988 has occurred in those harvest units containing recent blow-down, making it difficult to re-establish some plots.

The objectives of the 2003 evaluation were: (1) determine how many of the 1988 plots were still intact and (if locatable), (2) map all tagged trees and collect current tree information.

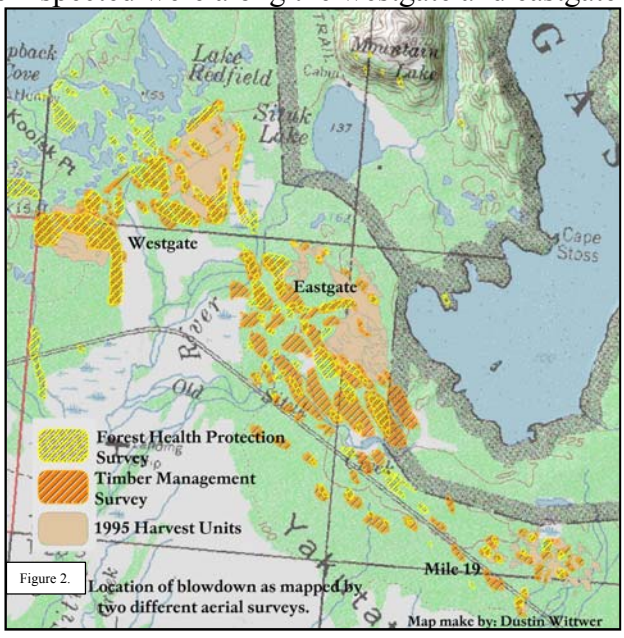
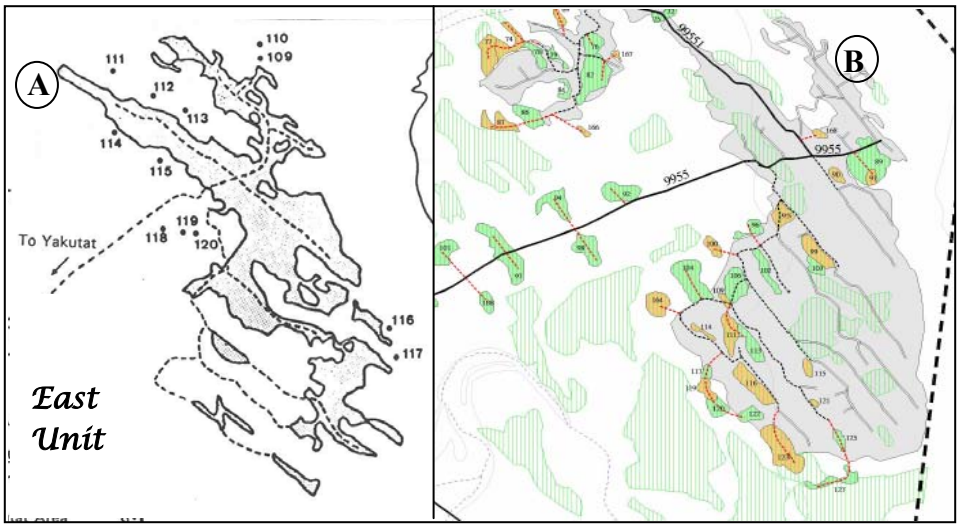


Figure 2. Location of blowdown as mapped by two different aerial surveys.

METHODS

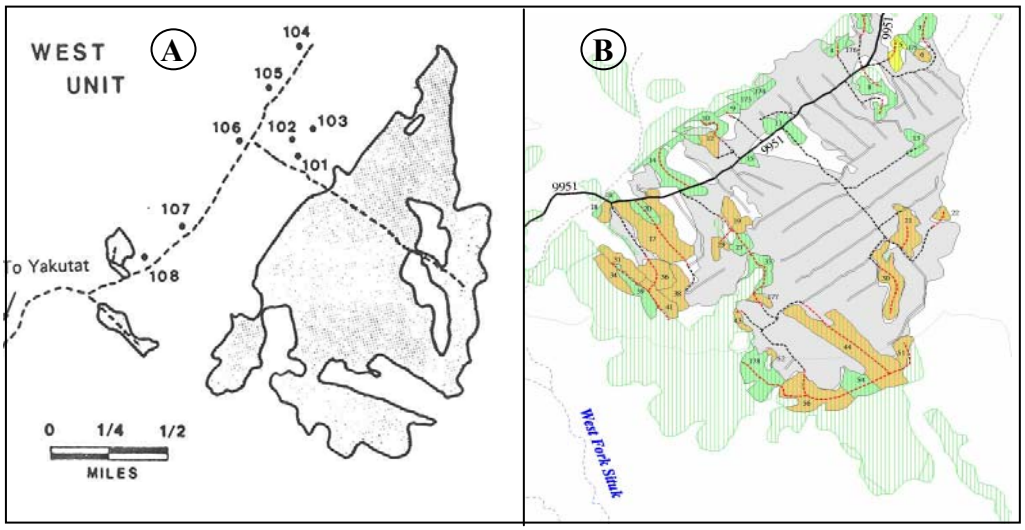
Nine of the 20 1988 plots were located. Plots 103, 104, and 105 were clear-cut logged (figures 3 and 4). Several attempts were made to locate plots 102, 107, 108, 109, 110, and 115 without success. Perhaps all plot trees were windthrown in a way that no tree tags were visible. No attempt was made to locate plots 116 and 117 because of the lack of access to the far end of the east unit.

Figure 3: A. East-gate units that were clearcut in 1982, and mortality plots established in 1988. B. 2003 timber sale map (from: Anonymous, 2003). The gray areas have already been harvested, the brown areas are proposed clearcuts, the solid green area-proposed sanitation cuts, and the hashed green areas-current blowdown.



Nine plots: 101, 106, 111-114, and 118-120 were re-established. All standing and down tagged trees were located by azimuth and distance from plot center . Tree condition (e.g. live, dead, down) for each tree was recorded and the cause of death determined. A GPS location was taken for each of the re-established plots. Classification and statistical analyses were done using the SAS Institute Inc. Enterprise program software.

Figure 4: A. West-gate units that were clearcut in 1982 and mortality plots established in 1988. B. 2003 timber sale map. The gray areas have already been harvested, the brown areas are proposed clearcuts, the solid green areas-proposed sanitation cuts, and the hashed green areas-current blowdown.



RESULTS AND DISCUSSION

It was difficult to find "sawdust" piles or frass piles (signs of current beetle attack) on tree bark and at the base of trees due to the extremely wet, rainy weather in August 2002. Some infested trees may have been over-looked. Only ambrosia beetle galleries were identified based upon close examination of tree boles. No spruce beetles were found in any of the windthrown trees. All ambrosia beetle infested trees were greater than 20 inches DBH and along the westgate road. No ambrosia beetle infested trees were found along the eastgate road or at mile 19. A few large Sitka spruce had older spruce beetle strip attacks. On these dead bark areas, pinicola (*Fomitopsis pinicola* (Swartz ex Fr.) Karst) conks were found. Extensive stem decay may occur where fully developed conks occurred in the lower and upper bole (Kimmy, 1956). When small 'popcorn' conks were found only in the lower bole extensive decay probably has not yet developed.

Many windthrown trees had some intact roots that allowed these trees to remain green and continue to grow. Most blowdown patches were small enough and shaded enough that foliage and phloem tissue were green and healthy looking in 2002. Spruce beetles may still attack these trees.

1988 data were collected on 367 and 443 Sitka spruce, 107 and 51 western hemlock, and 1 and 3 cottonwoods in the east and west unit plots, respectively. Seventy-one (19%) and 104 (23%) of the Sitka spruce were dead in the east and west units plots, respectively.

In 2003 the mean diameters of cottonwood and western hemlock were the same for east and west units. Mean diameter of live Sitka spruce was 12.0 and 14.5 inches for east and west plots,

respectively. On the nine plots, 87 and 279 Sitka spruce were recorded, 16 (18%) and 62 (22%) were dead in 1988, in the east and west plots, 39 (45%) and 121 (43%) were dead in 2003, respectively. This is approximately a doubling of mortality in 15 years. 80 and 74 percent of the Sitka spruce that were recorded as dead in 1988, in the east and west plots, respectively, had deteriorated to the point that they were broken snags or on the ground in 2003. 30 and 22 percent of the Sitka spruce recorded as live in 1988 were broken snags or on the ground in 2003.

No windthrow was recorded in 1988. Since 1988, 13 (33% of the dead trees) and 16 (13% of the dead trees) Sitka spruce died because they were windthrown in the east and west unit plots, respectively.

Spruce beetles killed a total of 19 and 79 Sitka spruce by 2003, 14 (74%) and 53 (67%) of these were spruce beetle kills in 1988, in the east and west plots, respectively.

The mean diameter of the 96 beetle killed Sitka spruce was 11.9 inches. The mean diameter of 66 dead Sitka spruce where spruce beetle was not found was 12.6 inches. Live Sitka spruce in 1988 that had pitch out attacks or strip attacks were two to three times, respectively, more likely to be successfully attacked by spruce beetle in 2003 than trees that had no attack history (figure 5). There was an association between unsuccessful beetle attacks in 1988 and bark beetle killed trees in 2003 ($\chi^2 = 18.8$, $P < .0001$). Spruce beetle attacked and killed trees had dominant canopy positions that might have made them more susceptible to attack.

Figure 5: Number* of Sitka spruce (expected number#) in each 2003 'spruce-beetle-attack' classification delineated by 1988 'spruce-beetle-attack' classifications.

1988	2003		TOTALS
	UNATTACKED	SUCCESSFUL	
UNATTACKED	**204***	**13**	**217**
	195#	22	
PITCH OUT ATTACK	**62**	**15**	**77**
	69	8	
STRIP ATTACK	**4**	**3**	**7**
	6	1	
TOTALS	**270**	**31**	**301**

Figure 6: Number* of dead Sitka spruce in 2003 (expected number[#] [within each agent]) in each 'spruce-beetle' classification by 'other-agent' classification.

BEETLES 2003	OTHER AGENTS 2003					
	ARMILLARIA		PINICOLA		AMBROSIA	
	NO	YES	NO	YES	NO	YES
UNATTACKED	**62***	**4**	**60**	**6**	**56**	**10**
	55[#]	11	40	26	47	19
SPRUCE BEETLE KILLED	**72**	**24**	**39**	**57**	**59**	**37**
	79	17	59	37	68	28
TOTALS	**134**	**28**	**99**	**63**	**115**	**47**

There was an association between spruce beetle killed trees (96 trees) and *Armillaria* sp. root disease ($\chi^2 = 9.8$, $P < .0018$), the presence of *F. pinicola* conks ($\chi^2 = 41.3$, $P < .0001$), and ambrosia [*Trypodendron lineatum* (Oliver)] beetle attacks ($\chi^2 = 10.3$, $P < .0013$)(figure 6). Emerging spruce beetles may carry *F. pinicola* spores that infect other trees as beetles attack. Ambrosia beetles have wood moisture requirements among other factors that attract them to recently dead trees, irrespective of the mortality agent. Armillaria is not known to be an aggressive root disease of conifers in southeast Alaska (Shaw and Loopstra, 1986) and probably needs a weakened or damaged tree for infection to occur. A bark beetle strip-attacked tree could also be a better host for Armillaria. Vegetative infection through the soil could occur from an infection source to the dead portion of the tree. This mode of infection does not possible for *F. pinicola*.

MANAGEMENT RECOMMENDATIONS

The forest stands of the Yakutat Forelands are prone to windthrow. Though spruce beetle outbreaks are of short duration in the Sitka spruce type, windthown trees continue to provide breeding material for the beetle. On the average, 1-2% of the Sitka spruce died per year since 1988. This rate of mortality is expected to occur in units that continue to have blowdown. **Much of this blowdown does not lead to new spruce beetle mortality.**

Few currently infested trees were found in 2002 and 2003, but down trees could still become infested and by 2006 spruce beetle mortality could occur in the standing live Sitka spruce. Forest Health Protection will continue to monitor the blowdown in 2004 both on the ground and during the annual aerial survey. As with the spruce beetle, ambrosia beetles will continue to attack down trees. Buildup of ambrosia beetles will NOT threaten standing green trees but can cause degrade in salvaged trees (Shore, 1998).

ACKNOWLEGMENTS

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LITERATURE CITED

Anonymous, 2003. Decision Notice Finding of No Significant Impact. Project Name: Yakutat Salvage Sale(s). USDA Forest Service. Tongass National Forest. Yakutat Ranger District. 24p.

Eglitis, A. 1988. Spruce Mortality in the Yakutat Forelands – 1987. USDA Forest Service, S&PF. Biological Evaluation R10-88-2. 9p.

Eglitis, A. 1989. Permanent Plots for Monitoring Spruce Mortality in the Yakutat Forelands. USDA Forest Service, S&PF. Biological Evaluation R10-89-16. 17p.

Kimmy, J.W. 1956. Cull factors for Sitka spruce, western hemlock, and western red cedar in southeast Alaska. USFS, Alaska Forest Research Center, Station Paper no. 6. 31p.

Mask, R. 1992. Spruce Beetle Activity in the Yakutat Forelands: 1991 Update. USDA Forest Service, Alaska Region, Forest Health Management. Biological Evaluation R10-TP-27. 8p.

Shaw, C.G. III, and E.M. Loopstra. 1986. Pathogenicity and identification of some Alaskan isolates of Armillaria. Phytopathology 76:1081.

Shore, T. L. 1998. "Ambrosia beetles." Canadian Forest Service, Pacific Forestry Centre Forest Pest Leaflet No. 72. 4p

APPENDIX A

SPRUCE BEETLE

Dendroctonus rufipennis (Kirby)

HOSTS: White, Lutz, Sitka and Black spruce.

DISTRIBUTION: Wherever spruce is found; a serious forest pest in south-central Alaska throughout Cook Inlet and Kenai Peninsula.

DAMAGE: Larvae feed beneath bark, usually killing affected trees.

DESCRIPTION: Adult spruce beetles are maroon to black, cylindrical in shape, approximately 5 mm long and 3 mm wide. Larvae are stout, white, legless grubs, 6 mm long when full-grown. The pupae are soft-bodied, white, and have some adult features.

BIOLOGY: The life cycle of the spruce beetle may vary from one to three years, with a two-year cycle being the most common. Temperature plays an important part in determining the length of time required for beetle development.

Adult beetles become active in the spring (late May to early June) when air temperatures reach a threshold of 16 ^{o}C (61^{o}F). At this time, beetles emerge from trees in which they overwintered and fly in search of new host material. These dispersal flights may be short-range even though beetles are capable of flying for several miles without stopping.

Spruce beetles prefer to attack the sides and bottom surfaces of windthrown or other downed materials which have been on the ground less than one year. In the absence of such host material, large-diameter live trees may be attacked instead, and if beetle populations are high, these trees may be killed.

Beetle attacks, whether on wind-thrown or on standing timber, are mediated by pheromones which insure that individual trees will be attacked "en masse", and fully colonized by subsequent broods. Trees that are mass-attacked form attractive centers which result in groups of trees being killed by spillover attacks.

Female beetles initiate attacks and begin constructing an egg gallery in the cambium parallel to the grain of the tree. They are joined by males and after mating, lay eggs in small niches along the sides of the egg gallery. Most eggs will hatch by August.

As they feed in the cambium, larvae construct their own galleries perpendicular to the egg gallery. Normally, spruce beetles pass the first winter in the larval stage, resume feeding the next spring, and pupate by summer. About two weeks later, pupae transform into adults which pass the second winter, either in the old pupation site, or more commonly, in the bases of infested trees. The following spring, two years after initial attack, the new adults emerge and

attack new host material. In some years when summer temperatures are above average, or on certain warmer micro-sites, spruce beetles may complete their development within one season and new adults will emerge one year after attack.

Most major outbreaks of spruce beetle have originated from stand disturbances that result in substantial accumulations of down, green, large diameter (> 8") spruce; e.g. blow-down, logging, or right-of-way clearance. Stand susceptibility to beetle attack is influenced by stocking, with slow growth and moisture stress playing an important part in predisposing trees to attack