

# Forest Health Protection



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## Hemlock Defoliation in North Idaho, Permanent Plot Establishment and Preliminary Results 2002-2004

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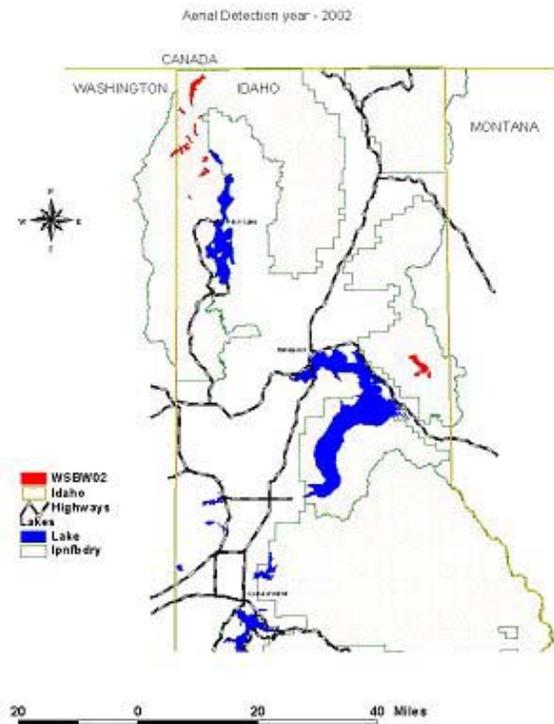
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### Background

In 2002 aerial surveyors detected areas of defoliation in western hemlock (*Tsuga heterophylla*) on the Priest Lake and Sandpoint Ranger Districts of the Idaho Panhandle National Forest (IPNF) (Figure 1). The causal agent was unknown. Follow up ground surveys found late instar larvae and adults of budworms, *Choristoneura* species (taxonomic findings are summarized in Appendix A).

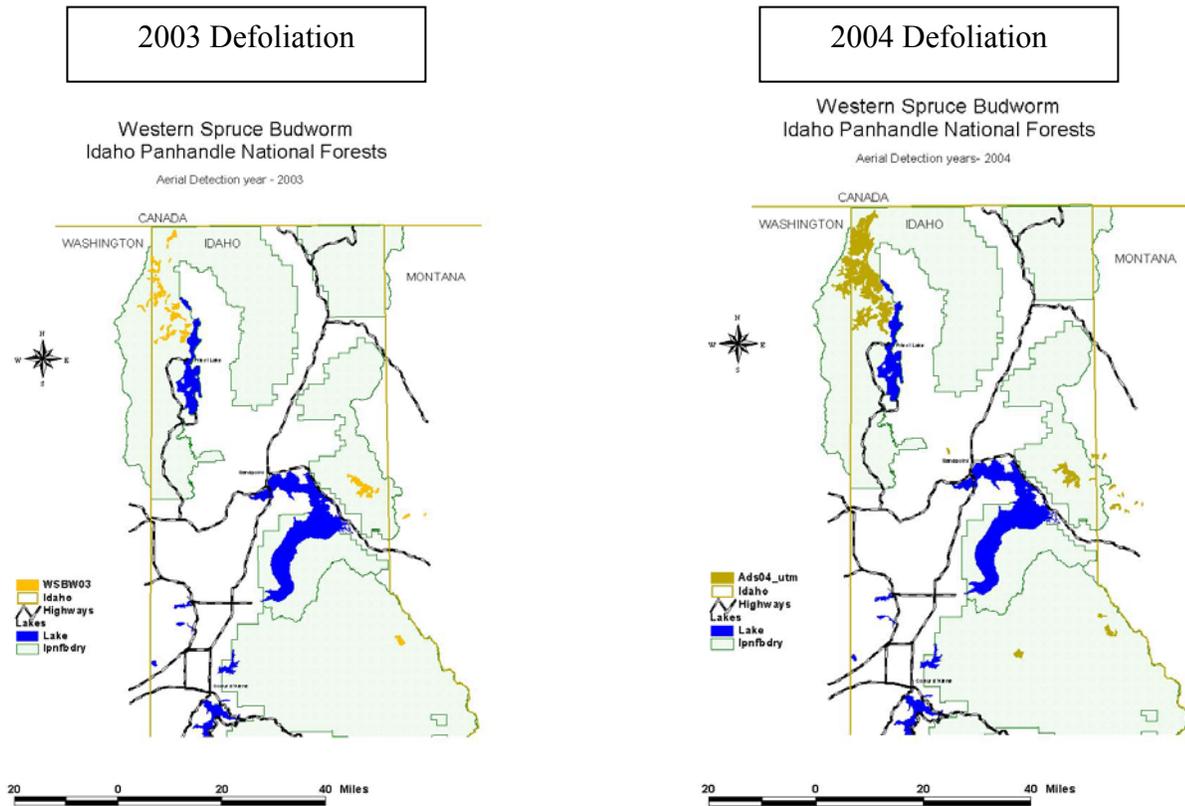
Defoliation was again mapped in 2003 and 2004, extending southward into the North Fork of the Coeur d'Alene River drainage (Figure 2).

There has only been one other report from 1921-1922 of western spruce budworm feeding on hemlock in this area. There was no information on losses sustained as a result of the 1920's defoliation. The current defoliation raises concerns about the potential impact moderate to severe defoliation may have on old growth hemlock.

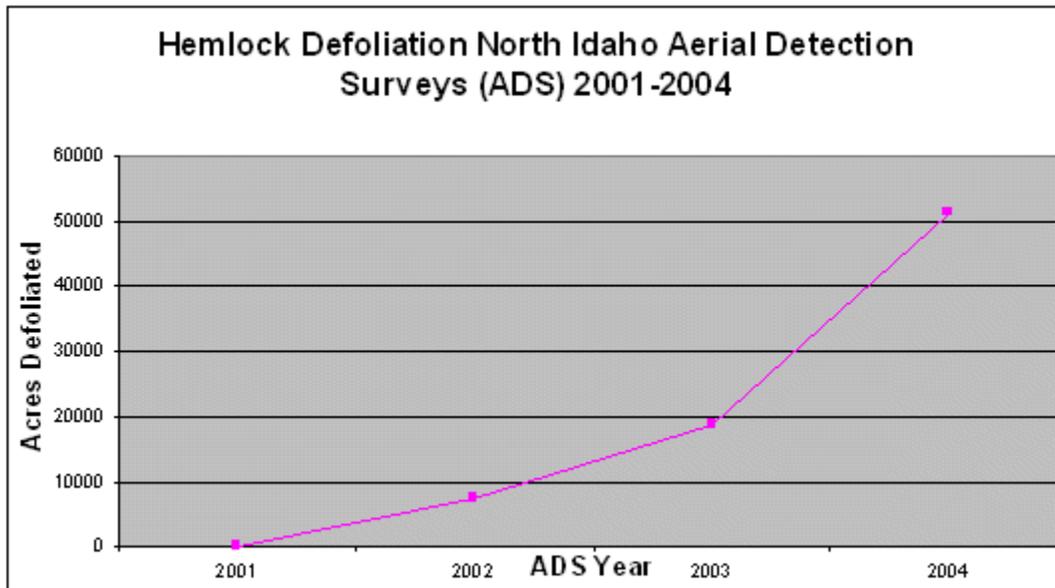


**Figure 1:** Hemlock defoliation mapped during aerial surveys in 2002. Subsequent ground surveys found larvae and adults in the genus *Choristoneura*.





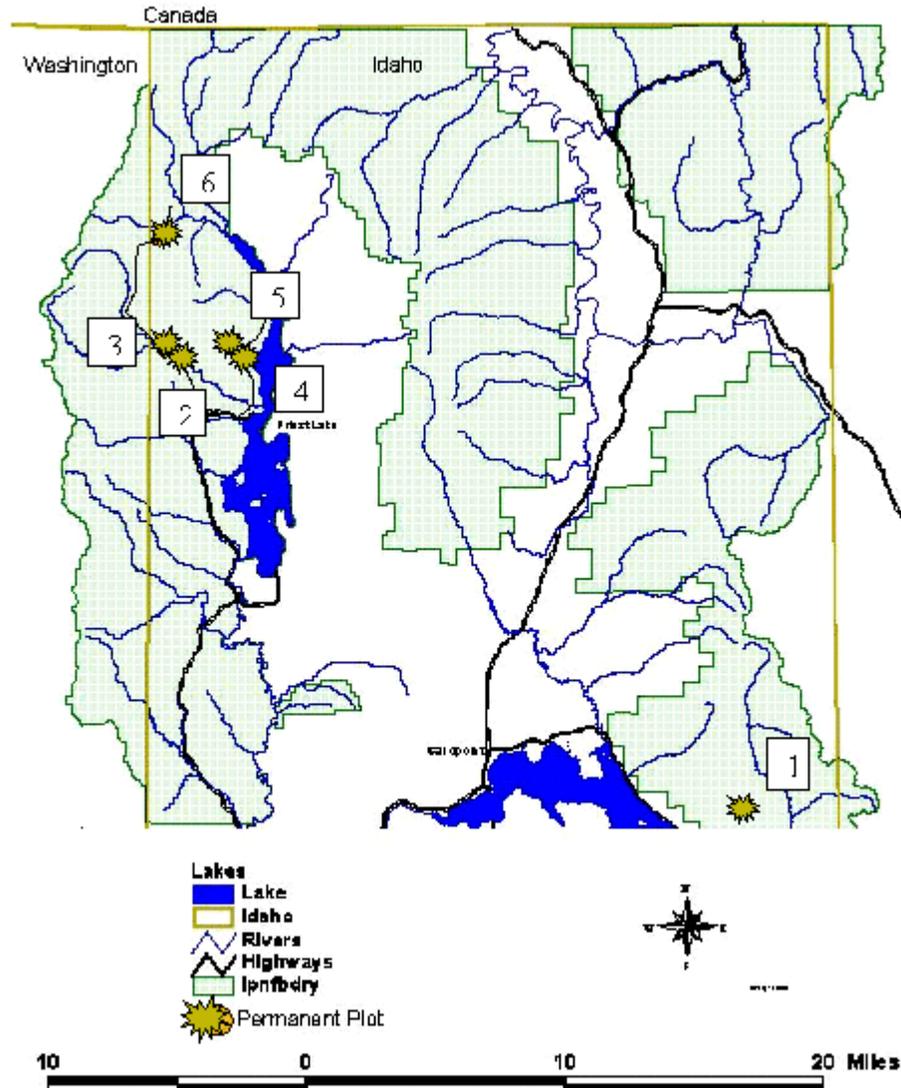
**Figure 2:** Hemlock defoliation mapped during aerial surveys in 2003 (left) and 2004 (right). Subsequent ground surveys found larvae and adults in the genus *Choristoneura*.



**Figure 3:** Acres of hemlock defoliation mapped on the Coeur d'Alene River, Sandpoint, and Priest Lake Ranger Districts, Idaho Panhandle National Forest during aerial surveys in 2002-2004.

## Permanent Plot Locations

Six defoliated areas were chosen and permanent plots were established to quantify current defoliation and tree damage (Figure 4).



**Figure 4:** Hemlock defoliation permanent plot locations, Sandpoint and Priest Lake Ranger Districts, Idaho Panhandle National Forests. 1= Porcupine Creek, 2= Granite Creek, 3= Athol Creek, 4= Distillery Bay, 5= Tango Creek, 6= South Fork of Gold Creek.

### Permanent Plot Methods

Five 1/20<sup>th</sup> acre fixed radius permanent plots were established along Porcupine Creek in the Lightning Creek drainage north of Clark Fork, Idaho in the fall of 2002. In the spring of 2003 five additional 1/20<sup>th</sup> acre plots were added

along Porcupine Creek and ten 1/20<sup>th</sup> acre permanent plots were established in each of the following areas: Athol Creek (2), Granite Creek (3), Distillery Bay (4), Tango Creek (5), and South Fork of Gold Creek (6) (Figure 4, Appendix B).

On each plot, hemlock and other traditional western spruce budworm host trees (Douglas-fir, grand fir, Engelmann spruce) 2 inches in diameter at breast height (DBH) and above were tagged and measured. Individual tree measurements included DBH and defoliation. A 1/100 acre fixed radius regeneration plot was established. In the regeneration plot seedling

and sapling (<2 inches DBH) were counted and rated for defoliation (Appendix C).

Defoliation rating were based on Twardus (1985) and involved visually dividing the tree crown into thirds and assigning a defoliation code to each level (lower, middle, and upper):

| Class | Percent Defoliation | Median Defoliation           |
|-------|---------------------|------------------------------|
| 1     | 0                   | No visible defoliation       |
| 2     | 1-25%               | 12.5%                        |
| 3     | 26-50%              | 38%                          |
| 4     | 51-75%              | 63%                          |
| 5     | 76-99%              | 88%                          |
| 6     | 100%                | No current year foliage left |

Crews were instructed to use binoculars and estimate defoliation on current year's foliage only.

Whole tree defoliation ratings were derived by adding the ratings for each crown 3<sup>rd</sup> and dividing by three.

### Stand Conditions in Plot Areas

Plot areas were selected based on the presence of visible defoliation in 2002/ 2003. Hemlock was the dominant overstory tree species in each of the 6 plot areas, though many also had western red cedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), western larch (*Larix occidentalis*) and white pine (*Pinus monticola*) components (Table 1, Appendix C).

**Table 1:** Overstory Stand Composition for 6 Hemlock Defoliation Permanent Plot Areas 2003, Sandpoint and Priest Lake Ranger Districts, Idaho Panhandle National Forest.

| Permanent Plot Area | Percent Stand Basal Area by Overstory Species |     |    |    |    |    |     |       |
|---------------------|---|-----|----|----|----|----|-----|-------|
|                     | WH  | WRC | GF | DF | WP | WL | SAF | Birch |
| Porcupine Creek     | 87  | 5   | 6  | 1  | 1  | 0  | 0   | 0     |
| Granite Creek       | 76  | 24  | 0  | 0  | 0  | 0  | 0   | 0     |
| Athol Creek         | 87  | 13  | 0  | 0  | 0  | 0  | 0   | 0     |
| Distillery Bay      | 46  | 17  | 16 | 3  | 5  | 7  | 0   | 7     |
| Tango Creek         | 78  | 18  | 4  | 0  | 0  | 0  | 0   | 0     |
| S Fork Gold Creek   | 91  | 8   | 0  | 0  | 0  | 0  | 1   | 0     |

WH = western hemlock; WRC = western red cedar; GF = grand fir; DF = Douglas-fir; WP = white pine, WL = western larch, SAF = subalpine fir, Birch = birch.

In most of the plot areas, the regeneration was hemlock dominated with minor components of other tree species (Table 2, Appendix C).

**Table 2:** Regeneration Species Composition for 6 Hemlock Defoliation Permanent Plot Areas 2003, Sandpoint and Priest Lake Ranger Districts, Idaho Panhandle National Forest.

| Permanent Plot Area | Trees per Acre by Species 0-4.9 DBH |      |     |    |    |    |     |        |
|---------------------|-------------------------------------|------|-----|----|----|----|-----|--------|
|                     | WH                                  | WRC  | GF  | DF | WP | ES | SAF | Junip. |
| Porcupine Creek     | 6510                                | 390  | 0   | 60 | 60 | 60 | 30  | 420    |
| Granite Creek       | 1830                                | 540  | 0   | 0  | 0  | 0  | 0   | 0      |
| Athol Creek         | 2910                                | 270  | 60  | 30 | 0  | 0  | 0   | 0      |
| Distillery Bay*     | 2850                                | 2070 | 300 | 0  | 90 | 0  | 0   | 7      |
| Tango Creek         | 1170                                | 1380 | 0   | 0  | 60 | 0  | 0   | 0      |
| S. Fork Gold Creek  | 2700                                | 300  | 0   | 0  | 0  | 60 | 150 | 0      |

\*also western larch 30 TPA, birch 90 TPA

WH = western hemlock; WRC = western red cedar; GF = grand fir; DF = Douglas-fir; WP = white pine, ES = Engelmann spruce, SAF = subalpine fir, Junip. = Juniper.

### Defoliation Summary 2002-2004

Defoliation was concentrated in the tops of trees, especially during the first year of visible defoliation. The severity of defoliation fluctuated

between plot areas and from year to year (Table 3, Appendix C).

**Table 3:** 2002-2004 Top 1/3<sup>rd</sup> and Whole Tree Average Defoliation Ratings for Overstory Trees on Six Hemlock Defoliation Plot Areas, Sandpoint and Priest Lake Ranger Districts, Idaho Panhandle National Forests.

| Plot Area             | # Trees  | 2002 |      | 2003 |      | 2004 |      |
|-----------------------|----------|------|------|------|------|------|------|
|                       |          | Top  | WT   | Top  | WT   | Top  | WT   |
| Porcupine Creek       | 52*/ 132 | 2.58 | 2.20 | 4.47 | 3.18 | 2.37 | 1.69 |
| Granite Creek         | 117      |      |      | 2.59 | 1.98 | 3.21 | 2.72 |
| Athol Creek           | 133      |      |      | 1.47 | 1.23 | 2.60 | 2.15 |
| Distillery Bay        | 186      |      |      | 1.97 | 1.62 | 2.4  | 2.16 |
| Tango Creek           | 53       |      |      | 4.81 | 3.92 | 4.36 | 3.91 |
| South Fork Gold Creek | 130      |      |      | 3.15 | 2.42 | 4.0  | 3.48 |

\*In 2002 only 5 plots had been established along Porcupine Creek with a total of 52 trees.

Very few trees have experienced 100% defoliation (defoliation rating = 6) in any crown third (2002-2004) (Table 4; Appendix C).

**Table 4:** Number of Trees with a Top 1/3<sup>rd</sup> Defoliation Rating of 5 (76-99% Defoliation) or 6 (100% defoliation) in 2002, 2003, and 2004 for Six Hemlock Defoliation Plot Areas, Sandpoint and Priest Lake Ranger Districts, Idaho Panhandle National Forests.

| Plot Area             | # Trees  | 2002 |   | 2003 |    | 2004 |    |
|-----------------------|----------|------|---|------|----|------|----|
|                       |          | 6    | 5 | 6    | 5  | 6    | 5  |
| Porcupine Creek       | 52*/ 132 | 0    | 2 | 45   | 37 | 9    | 8  |
| Granite Creek         | 117      |      |   | 5    | 9  | 0    | 20 |
| Athol Creek           | 133      |      |   | 0    | 2  | 0    | 9  |
| Distillery Bay        | 186      |      |   | 0    | 2  | 1    | 1  |
| Tango Creek           | 53       |      |   | 12   | 25 | 4    | 24 |
| South Fork Gold Creek | 130      |      |   | 15   | 18 | 18   | 41 |

### **Sandpoint Ranger District: Porcupine Creek**

The Porcupine Creek plot area is the only area located on the Sandpoint Ranger District, IPNF. It is also the only area with defoliation data from 2002-2003. The stand is mostly composed of western hemlock, with some Douglas-fir, grand fir, subalpine fir, and Engelmann spruce. Hemlock was the most heavily defoliated species in the stand. In 2002 the top 1/3<sup>rd</sup> average defoliation rating was a 2.8, in 2003 a 4.7, and in 2004 a 2.5, indicating a possible declining trend.

Defoliation on the regeneration plots was limited to hemlock trees and was again highest in 2003, followed by 2002. In 2004 no defoliation in the hemlock regeneration was noted (Appendix C).

### **Priest Lake Ranger District**

Hemlock is the dominant overstory species in all 5-plot areas located on the Priest Lake Ranger District. Other species present include western red cedar, grand fir, Douglas fir, western larch, white pine, and subalpine fir. All plots in Priest Lake were established in 2003. Plot area average defoliation ratings for the top 1/3<sup>rd</sup> and whole tree generally increased or stayed the same from 2003-2004.

### **Granite Creek**

Only two tree species were present in the overstory of the Granite Creek Plot Area, hemlock (89% of the TPA) and western red cedar (11% of the TPA).

In 2003, minor defoliation was noted only in hemlock regeneration. In 2004, some defoliation was noted in western red cedar regeneration and the intensity of hemlock regeneration defoliation increased (Appendix C Table 8).

### **Athol Creek**

As in Granite Creek the only overstory tree species in the Athol Creek plots are hemlock (98% of the TPA) and western red cedar (2% of the TPA). Western red cedar is not considered a host for the western spruce budworm so defoliation ratings were only taken on hemlock.

The average defoliation intensity increased in this plot area from 2003-2004 (Table 3).

In 2003, there was no defoliation noted in the regeneration in the Athol Creek Plots. In 2004, defoliation was noted on hemlock, western red cedar, and grand fir regeneration; it was most intense (highest defoliation ratings) on grand fir regeneration (Appendix C Table 12).

### **Distillery Bay**

The Distillery Bay plot area has a more mixed conifer composition than the other defoliation plot areas; hemlock comprises ~ 51% of the TPA, followed in abundance by western red cedar (14% of the TPA), grand fir (12% of the TPA), birch (11% of the TPA), western larch (6% of the TPA), western white pine and Douglas-fir (both ~ 3% of the TPA). The average defoliation intensity increased in the overstory of this plot area from 2003 – 2004 (Table 3; Appendix C Table 15). No regeneration was noted.

### **Tango Creek**

The Tango Creek plot area is a hemlock-dominated forest (72% of the TPA) with cedar (21% of the TPA) and grand fir (6% of the TPA) also present in the overstory. Defoliation has been present on both overstory hemlock and grand fir, with the average defoliation intensity higher on the grand fir (Appendix C Table 18).

The regeneration measured in the plot was composed of hemlock, white pine, and cedar; hemlock was the most significantly defoliated (Appendix C Table 19).

### **South Fork of Gold Creek**

The South Fork of Gold Creek plot area is largely composed of hemlock (97% of the TPA) with minor amounts of subalpine fir (2% of the TPA) and cedar (1% of the TPA). Plot level average defoliation intensity ratings increased from 2003-2004. Average overstory subalpine fir defoliation intensity ratings were higher than average overstory hemlock defoliation intensity ratings in 2003 but not 2004 (Appendix C Table 22).

In 2003, hemlock was the only regeneration species to have measurable defoliation, in 2004 regenerating Engelmann spruce and subalpine

fir had higher defoliation intensity ratings than

## Conclusion

The area affected by hemlock defoliation increased in 2004 from 2003 levels. While the intensity of defoliation appeared to decrease in the Porcupine Creek plot area on the Sandpoint Ranger District from 2003-2004, it increased or stayed the same on the other 5 plot areas on the Priest Lake Ranger District.

Collections of larvae from defoliated areas indicate a complex of 4 or 5 *Choristoneura* species are responsible (Appendix A), though *Choristoneura occidentalis*, the western spruce budworm, is the most abundant. Lower crown sampling has to date been unable to uncover any of the more frequently encountered hemlock

hemlock (Appendix C Table 23).

defoliators such as the western blackheaded budworm (*Acleris gloverana*), western hemlock looper (*Lambdina fiscellaria*), and western false hemlock looper (*Nepytia freemani*). Only a few individual sawflies (*Neodeprion* spp.) were observed during sampling, not enough to result in the level of defoliation currently being observed.

The last reported incident of western spruce budworm defoliation in hemlock occurred in the Priest Lake area in 1922. Records from that outbreak are incomplete.

We will continue to monitor our permanent plots until the defoliation stops.

## Literature Cited

Twardus, D.B. 1985. Surveys and sampling methods for population and damage assessment. In: Brookes, M.H., Bolbert, J.J.; Mitchell, R.G.; Stark, R.W., editors. Managing trees and stands susceptible to the western spruce budworm. Tech. Bull. 1695. Washington, D.C: U.S. Department of Agriculture, Forest Service; 27-40.

## Appendix A: Taxonomic Information, Hemlock Defoliation North Idaho 2003-2004

### 2003

In 2003, 18 adult moths were collected in areas of hemlock defoliation in north Idaho (Bonner and Boundary County) and 5 adult moths were collected in areas of hemlock defoliation in western Montana (Lincoln County). All moths were sent to Frank W. Merickel, curator WF Barr

Entomological Museum, University of Idaho. Mr. Merickel then forwarded the pinned moths onto a Tortricid specialist for definitive identification.

All of the 23 moths sent in for identification were Tortricids in the genus *Choristoneura*. There were four species found (Table 1).

**Table 1:** 2003 identification of *Choristoneura* species collected from areas of hemlock defoliation in northern Idaho and western Montana.

| Number | Genus species                     | Location  |
|--------|-----------------------------------|---|
| 6      | <i>Choristoneura orae</i>         | Bonner Co, ID   |
| 12     | <i>Choristoneura occidentalis</i> | 5 in Bonner Co, ID; 4 in Lincoln Co, MT; 3 in Boundary Co, ID |
| 1      | <i>Choristoneura lambertiana</i>  | 1 in Bonner Co, ID  |
| 4      | <i>Choristoneura retiniana</i>    | 1 in Boundary Co, ID; 2 in Bonner Co, ID                      |

### 2004

In 2004, personnel from the Priest Lake Ranger District collected a number of branch samples from defoliated trees. The branch samples were sent to Carol Randall, Forest Health Protection Entomologist in Coeur d'Alene. Carol removed larvae from each branch sample and reared the larvae on the host from which they had been collected. As the larvae began to pupate, Carol

forwarded them to Frank Merickel, curator WF Barr Entomological Museum, University of Idaho, for specimen preparation and identification.

The 2004 host rearing resulted in 28 moths representing 5 *Choristoneura* species (Table 2) as determined by Ron Leuschner. Mr. Merickel also reared out 8 Ichneumonid parasites.

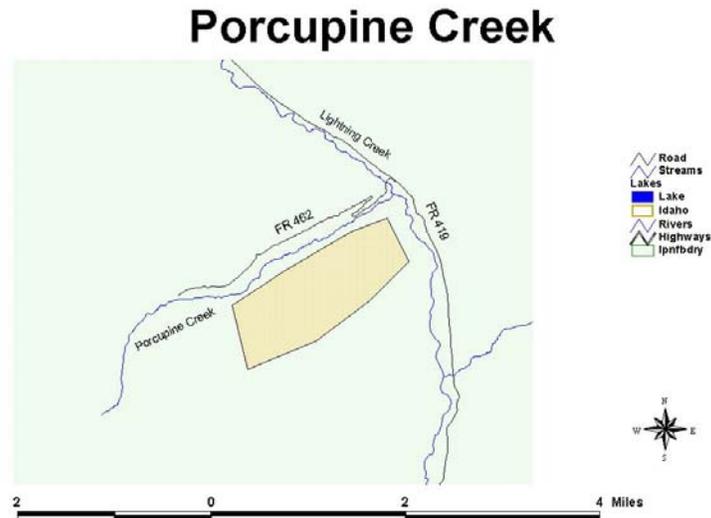
**Table 2:** 2004 identification of *Choristoneura* species collected from areas of hemlock defoliation in northern Idaho on the Priest Lake Ranger District, Idaho Panhandle National Forest.

| Number | Genus species                     |
|--------|-----------------------------------|
| 4      | <i>Choristoneura orae</i>         |
| 18     | <i>Choristoneura occidentalis</i> |
| 1      | <i>Choristoneura lambertiana</i>  |
| 2      | <i>Choristoneura retiniana</i>    |
| 1      | <i>Choristoneura fumiferana</i> * |

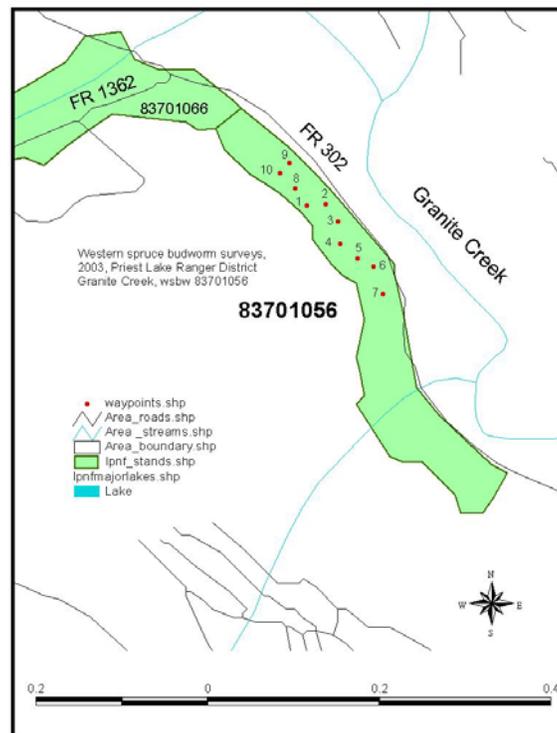
\* 2 additional moths are still pending species identification, are thought to also be *C. fumiferana*

## Appendix B: Permanent Plot Maps for Six Areas Monitored for Hemlock Defoliation

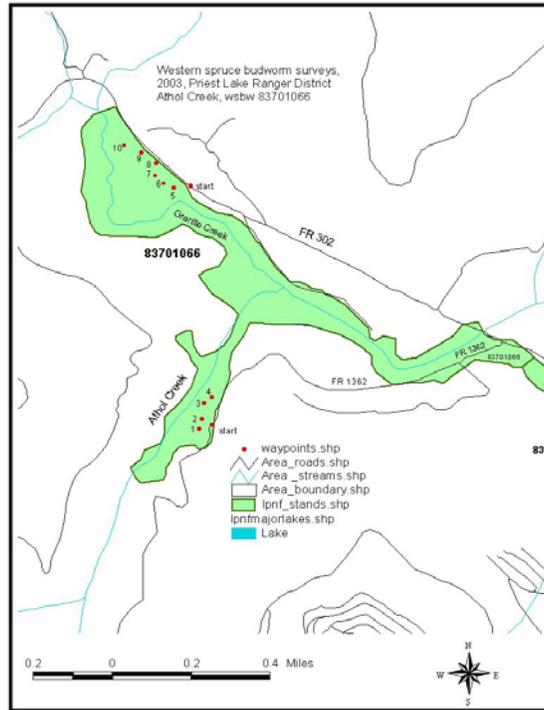
**Area 1:** Porcupine Creek Hemlock Defoliation plots area on the Sandpoint Ranger District, IPNF. Individual plots were not GPS-ed as of date of this report. Five plots were established fall 2002, 5 additional plots were established in 2003.



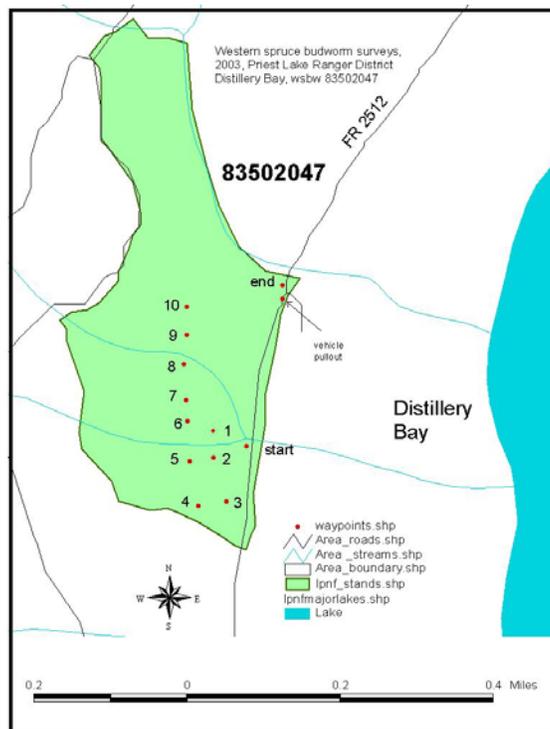
**Area 2:** Granite Creek Hemlock Defoliation plots area on the Priest Lake Ranger District, IPNF. Ten plots were established in 2003.



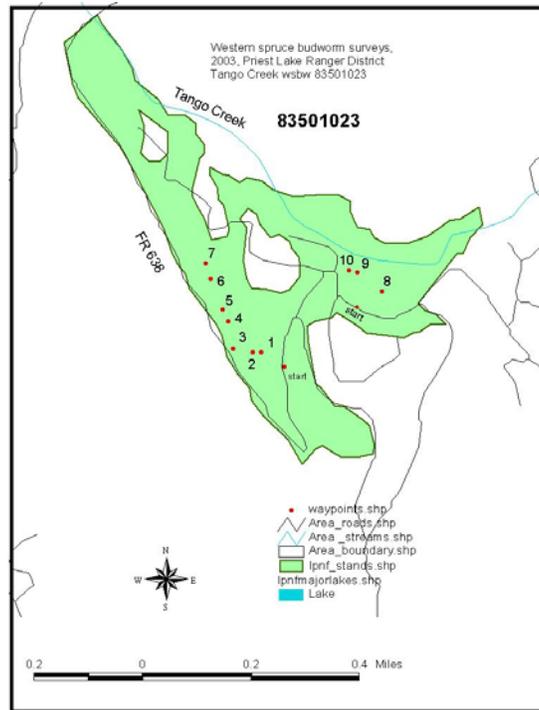
**Area 3:** Athol Creek Hemlock Defoliation plots area on the Priest Lake Ranger District, IPNF. Ten plots were established in 2003.



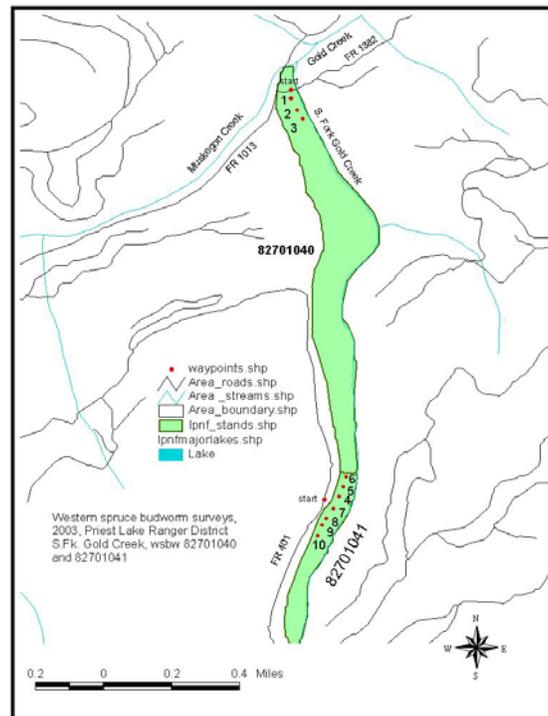
**Area 4:** Distillery Bay Hemlock Defoliation plots area on the Priest Lake Ranger District, IPNF. Ten plots were established in 2003.



**Area 5:** Tango Creek Hemlock Defoliation plots area on the Priest Lake Ranger District, IPNF. Ten plots were established in 2003.



**Area 6:** South Fork Gold Creek Hemlock Defoliation plots area on the Priest Lake Ranger District, IPNF. Ten plots were established in 2003.



## Appendix C: Preliminary Permanent Plot Results

### Porcupine Creek

The Porcupine Creek Plots are the only ones located on the Sandpoint Ranger District, IPNF. The first 5 plots in the 10-plot area were established in the fall of 2002, the first year of visible defoliation.

### Stand Conditions

Western hemlock (hemlock) was the dominant tree species in the overstory and regeneration

plots in the Porcupine Creek permanent plots (Tables 1 and 2). Approximately 85% of the overstory trees per acre (TPA) were hemlock, with western red cedar (5% TPA), grand fir (5% TPA), white pine (3% TPA) and Douglas-fir (1% TPA) also present. The regeneration was also dominated by hemlock seedlings/ saplings (85% TPA) with juniper (~6% TPA) and western red cedar (5% TPA) and minor numbers of subalpine fir, spruce, western white pine, and Douglas-fir seedling/ sapling trees per acre.

**Table 1:** Stand summary information for Porcupine Creek Defoliation Permanent Plots in 2003.

| Species           | Trees/ Acre | Basal Area | Quadratic Mean Diameter | % Stand Basal Area | % Stand Trees/ Acre |
|-------------------|-------------|------------|-------------------------|--------------------|---------------------|
| Grand Fir         | 22          | 10         | 9                       | 6                  | 5                   |
| White Pine        | 14          | 2          | 5                       | 1                  | 3                   |
| Douglas-Fir       | 4           | 2          | 9                       | 1                  | 1                   |
| Western Red Cedar | 21          | 8          | 9                       | 5                  | 5                   |
| Western Hemlock   | 351         | 142        | 10                      | 87                 | 85                  |
| <b>TOTAL</b>      | <b>411</b>  | <b>164</b> | <b>9</b>                | <b>100</b>         | <b>100</b>          |

**Table 2:** Stand regeneration trees per acre summary information for Porcupine Creek Defoliation Permanent Plots in 2003.

| Species            | TPA 00 - 2.9 DBH | TPA 3.0 - 4.9 DBH | TOTAL       |
|--------------------|------------------|-------------------|-------------|
| Subalpine Fir      | 30               | 0                 | 30          |
| Juniper            | 420              | 0                 | 420         |
| Spruce             | 60               | 0                 | 60          |
| Western White Pine | 30               | 30                | 60          |
| Douglas-fir        | 60               | 0                 | 60          |
| Western Red Cedar  | 300              | 90                | 390         |
| Western Hemlock    | 5430             | 1080              | 6510        |
| <b>TOTAL</b>       | <b>6330</b>      | <b>1200</b>       | <b>7530</b> |

### Defoliation Summary

Five of the 10 permanent plots were established in 2002 along Porcupine Creek. A total of 10 plots were measured in 2003 and 2004 (Table 3). The hemlock trees were defoliated more

significantly (higher defoliation ratings) than the other species. For defoliated plot trees, the top third was usually more heavily defoliated than the middle and lower third. For the three years of data available, defoliation ratings were highest in 2003, followed by 2002 and 2004.

**Table 3:** Defoliation rating summary for overstory trees in permanent plots along Porcupine Creek, Sandpoint Ranger District, Idaho Panhandle National Forest 2002-2004.

| Species | # Trees** | Avg DBH | Min DBH | Max DBH | 2002 Ratings*  |                |                | 2003 Ratings*  |                |                | 2004 Ratings*  |                |                |
|---------|-----------|---------|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |           |         |         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| SAF     | 1         | 2.8     | 2.8     | 2.8     | 1              | 1              | 1              | 3              | 2              | 2              | 1              | 1              | 1              |
| DF      | 4         | 9.2     | 2.2     | 23.2    | 2              | 2              | 2              | 2.8            | 2.3            | 2              | 2.3            | 1.5            | 1.3            |
| GF      | 6         | 8.2     | 2       | 11.2    | 1.7            | 2              | 2              | 2.3            | 2              | 2              | 1              | 1.2            | 1              |
| S       | 2         | 2.55    | 2.4     | 2.7     | 1              | 1              | 1              | 2              | 2              | 1              | 1              | 1              | 1              |
| WH      | 119       | 8.94    | 2       | 45.1    | 2.8            | 2.1            | 2              | 4.7            | 3.1            | 2              | 2.5            | 1.5            | 1.3            |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100%

\*\* In 2002 with only 5 plots tree numbers were as follow: SAF 1; DF 3; GF 3; S 2; WH 43

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

SAF = subalpine fir; DF= Douglas-fir; GF = grand fir; S = Engelmann spruce; WH = western hemlock

Average plot defoliation ratings were the highest in 2003 when the plot average top 1/3<sup>rd</sup> defoliation rating for hemlock was 4.7, or between 51-75% defoliated. In that year 45 plot trees (44 hemlock and 1 Douglas-fir) had a top 1/3<sup>rd</sup> defoliation rating of 6 (100%) and 37 trees (all hemlocks) had a top 1/3<sup>rd</sup> defoliation rating of 5 (76-99%). In 2004, the average plot level defoliation rating had decreased. The top 1/3<sup>rd</sup> in hemlock trees was 2.5, or between 1-25% defoliated, and only 8 plot trees, all hemlock,

had a top 1/3<sup>rd</sup> defoliation rating of 6, and 8 plot hemlock trees had a top 1/3<sup>rd</sup> defoliation rating of 5.

Defoliation on the regeneration plots was limited to hemlock trees and was again highest in 2003, followed by 2002, and in 2004 no current defoliation in the hemlock regeneration was noted (Table 4).

**Table 4:** Defoliation rating summary for regenerating trees in permanent plots along Porcupine Creek, Sandpoint Ranger District, Idaho Panhandle National Forest 2002-2004.

| Species | # Trees** | 2002 Ratings*  |                |                | 2003 Ratings*  |                |                | 2004 Ratings*  |                |                |
|---------|-----------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |           | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WRC     | 3         | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              |
| PY      | 11        | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 1              |
| WH      | 7         | 1.5            | 1.5            | 1.5            | 3              | 2.4            | 2              | 1              | 1              | 1              |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100%

\*\* In 2002 with 5 plots tree numbers were as follow WRC 1; PY 1; WH 4

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

WRC = western red cedar; PY = Pacific yew; WH = western hemlock

### Granite Creek

The Granite Creek Plots were established in 2003 on the Priest Lake Ranger District, IPNF.

### Stand Conditions

The Granite Creek plot area is a hemlock-dominated forest with hemlock comprising 89% of the TPA in the overstory and 77% of the regeneration TPA. The only other tree species present was western red cedar (Tables 5 and 6).

**Table 5:** Stand summary information for Granite Creek Defoliation Permanent Plots in 2003.

| Species           | Trees/ Acre | Basal Area | Quadratic Mean Diameter | % Stand Basal Area | % Stand Trees/ Acre |
|-------------------|-------------|------------|-------------------------|--------------------|---------------------|
| Western Red Cedar | 42          | 46         | 24                      | 24                 | 11                  |
| Western Hemlock   | 351         | 144        | 9                       | 76                 | 89                  |
| <b>TOTAL</b>      | <b>393</b>  | <b>190</b> | <b>10</b>               | <b>100</b>         | <b>100</b>          |

**Table 6:** Stand regeneration trees per acre summary information for Granite Creek Defoliation Permanent Plots in 2003.

| Species           | TPA 00 - 2.9 DBH | TPA 3.0 - 4.9 DBH | TOTAL       |
|-------------------|------------------|-------------------|-------------|
| Western Red Cedar | 360              | 180               | 540         |
| Western Hemlock   | 1080             | 750               | 1830        |
| <b>TOTAL</b>      | <b>1440</b>      | <b>930</b>        | <b>2370</b> |

**Defoliation Summary**

The crew did not measure defoliation on cedar for the overstory plot trees. Hemlock defoliation

ratings were higher in 2004 than in 2003, and in both years the top 1/3<sup>rd</sup> of hemlock trees were more heavily defoliated than the bottom 2/3<sup>rd</sup>s (Table 7).

**Table 7:** Defoliation rating summary for overstory trees in permanent plots along Granite Creek, Priest Lake Ranger District, Idaho Panhandle National Forest 2002-2004.

| Species | # Trees | Avg DBH | Min DBH | Max DBH | 2003Ratings*   |                |                | 2004 Ratings*  |                |                |
|---------|---------|---------|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |         |         |         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WH      | 117     | 10.09   | 2       | 38.1    | 2.6            | 1.9            | 1.4            | 3.3            | 2.7            | 2.2            |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100% WH = western hemlock

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

Average plot defoliation ratings were the highest in 2004 when the plot average top 1/3<sup>rd</sup> defoliation rating for hemlock was 3.3, or between 26-50% defoliated. In that year 20 plot trees had a top 1/3<sup>rd</sup> defoliation rating of 5 (76-99%). In 2003, the average plot level defoliation rating was lower, however there were trees in 2003 that had a top 1/3<sup>rd</sup> defoliation rating of 6 (100%). The average top 1/3<sup>rd</sup> defoliation rating for the plots were 2.5, or between 1-25%

defoliated, but 5 plot trees had a top 1/3<sup>rd</sup> defoliation rating of 6, and 9 plot trees had a top 1/3<sup>rd</sup> defoliation rating of 5.

In 2003 minor defoliation was noted only on hemlock seedling/ saplings. In 2004 minor defoliation was noted on cedar regeneration; hemlock regeneration defoliation was more intense than it had been in 2003 (Table 8).

**Table 8:** Defoliation rating summary for regeneration plot trees in permanent plots along Granite Creek, Priest Lake Ranger District, Idaho Panhandle National Forest 2002-2004.

| Species | # Trees | 2003 Ratings*  |                |                | 2004 Ratings*  |                |                |
|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WRC     | 7       | 1              | 1              | 1              | 1.3            | 1              | 1              |
| WH      | 5       | 1.4            | 1              | 1              | 3.2            | 2.8            | 2.6            |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100% WRC = western red cedar; WH = western hemlock

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown, <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown, <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

**Athol Creek**

The Athol Creek plots were established in 2003 on the Priest Lake Ranger District, IPNF.

**Stand Conditions**

The Athol Creek plot area is a hemlock-dominated forest with hemlock comprising 98%

of the TPA in the overstory and 90% of the regeneration TPA. The only other tree species present in the overstory was western red cedar (Table 9). Hemlock dominated the regeneration, with smaller components of western red cedar, Douglas-fir, and grand fir regeneration (Table 10).

**Table 9:** Stand summary information for overstory trees Athol Creek Defoliation Permanent Plots in 2003.

| Species           | Trees/ Acre | Basal Area | Quadratic Mean Diameter | % Stand Basal Area | % Stand Trees/ Acre |
|-------------------|-------------|------------|-------------------------|--------------------|---------------------|
| Western Red Cedar | 9           | 26         | 27                      | 13                 | 2                   |
| Western Hemlock   | 463         | 176        | 9                       | 87                 | 98                  |
| <b>TOTAL</b>      | <b>472</b>  | <b>202</b> | <b>10</b>               | <b>100</b>         | <b>100</b>          |

**Table 10:** Stand regeneration trees per acre summary information for Athol Creek Defoliation Permanent Plots in 2003.

| Species           | TPA 00 - 2.9 DBH | TPA 3.0 - 4.9 DBH | TOTAL       |
|-------------------|------------------|-------------------|-------------|
| Grand Fir         | 60               | 0                 | 60          |
| Douglas- Fir      | 30               | 0                 | 30          |
| Western Red Cedar | 240              | 30                | 270         |
| Western Hemlock   | 2160             | 750               | 2910        |
| <b>TOTAL</b>      | <b>2490</b>      | <b>780</b>        | <b>3270</b> |

**Defoliation Summary**

The crew did not measure defoliation on cedar for the overstory plot trees. Hemlock defoliation

ratings were higher in 2004 than in 2003, and in both years the top 1/3<sup>rd</sup> of hemlock trees were more heavily defoliated than the bottom 2/3<sup>rd</sup>s (Table 11).

**Table 11:** Defoliation rating summary for overstory trees in permanent plots along Athol Creek, Priest Lake Ranger District, Idaho Panhandle National Forest 2002-2004.

| Species | # Trees | Avg DBH | Min DBH | Max DBH | 2003Ratings*   |                |                | 2004 Ratings*  |                |                |
|---------|---------|---------|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |         |         |         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WH      | 117     | 10.09   | 2       | 38.1    | 2.6            | 1.9            | 1.4            | 3.3            | 2.7            | 2.2            |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100%      WH = western hemlock

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

Grand fir regeneration was most heavily defoliated, followed by hemlock and cedar. No defoliation was observed on Douglas-fir regeneration.

**Table 12:** Defoliation rating summary for regeneration plot trees in permanent plots along Athol Creek, Priest Lake Ranger District, Idaho Panhandle National Forest 2003-2004.

| Species | # Trees | 2003Ratings*   |                |                | 2004 Ratings*  |                |                |
|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WH      | 11      | 1              | 1              | 1              | 2              | 1.5            | 1.5            |
| WRC     | 4       | 1              | 1              | 1              | 1.75           | 1.25           | 1.25           |
| GF      | 1       | 1              | 1              | 1              | 3              | 2              | 2              |
| DF      | 1       | 1              | 1              | 1              | 1              | 1              | 1              |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100%      WRC = western red cedar; WH = western hemlock; GF= grand fir;

DF= Douglas-fir

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

### Distillery Bay

The Distillery Bay plots were established in 2003 on the Priest Lake Ranger District, IPNF. Western hemlock trees were more heavily defoliated than grand fir and Douglas-fir trees on the plots.

### Stand Conditions

The Distillery Bay plot area is a mixed conifer forest with hemlock comprising 51% of the TPA

in the overstory. Additional overstory species include slightly larger (QMD = 11) western red cedar (14% TPA), grand fir (12% TPA), birch (11% TPA) with occasional larch (6% TPA), western white pine (3%TPA) and Douglas-fir (3% TPA) (Table 13). Hemlock and western red cedar dominated the regeneration, with grand fir, western white pine, birch, and larch also present (Table 14).

**Table 13:** Stand summary information for Distillery Bay Defoliation Permanent Plots in 2003.

| Species            | Trees/ Acre | Basal Area | Quadratic Mean Diameter | % Stand Basal Area | % Stand Trees/ Acre |
|--------------------|-------------|------------|-------------------------|--------------------|---------------------|
| Larch              | 51          | 20         | 8                       | 7                  | 6                   |
| Grand Fir          | 106         | 48         | 11                      | 16                 | 12                  |
| Western White Pine | 23          | 14         | 15                      | 5                  | 3                   |
| Douglas-fir        | 30          | 10         | 8                       | 3                  | 3                   |
| Western Red Cedar  | 119         | 50         | 11                      | 17                 | 14                  |
| Western Hemlock    | 441         | 138        | 8                       | 46                 | 51                  |
| Birch              | 93          | 20         | 6                       | 7                  | 11                  |
| <b>TOTAL</b>       | <b>862</b>  | <b>300</b> | <b>8</b>                | <b>100</b>         | <b>100</b>          |

**Table 14:** Stand regeneration trees per acre summary information for Distillery Bay Defoliation Permanent Plots in 2003.

| Species            | TPA 00 - 2.9 DBH | TPA 3.0 - 4.9 DBH | TOTAL       |
|--------------------|------------------|-------------------|-------------|
| Larch              | 0                | 30                | 30          |
| Grand Fir          | 150              | 150               | 300         |
| Western White Pine | 30               | 60                | 90          |
| Western Red Cedar  | 1680             | 390               | 2070        |
| Western Hemlock    | 1410             | 1440              | 2850        |
| Birch              | 0                | 90                | 90          |
| <b>TOTAL</b>       | <b>3270</b>      | <b>2160</b>       | <b>5430</b> |

**Defoliation Summary**

Overall defoliation ratings were higher in 2004 than in 2003, and in both years the top 1/3<sup>rd</sup> of plot trees were more heavily defoliated than the bottom 2/3rds (Table 15). Individual tree defoliation ratings were lower on the Distillery

Bay plots than in some others, with only 2 trees (1 hemlock and 1 grand fir) receiving a top 1/3<sup>rd</sup> defoliation rating of 5 in 2003 (no 6 ratings) and in 2004 only one 6 and one 5 in the top 1/3<sup>rd</sup> of the crown (both hemlocks). The crew did not measure defoliation on regeneration plot in Distillery Bay.

**Table 15:** Defoliation rating summary for overstory trees in permanent plots along Distillery Bay, Priest Lake Ranger District, Idaho Panhandle National Forest 2002-2004.

| Species | # Trees | Avg DBH | Min DBH | Max DBH | 2003Ratings*   |                |                | 2004 Ratings*  |                |                |
|---------|---------|---------|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |         |         |         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WH      | 148     | 6.5     | 2       | 16.9    | 2              | 1.6            | 1.3            | 2.5            | 2.1            | 2              |
| GF      | 33      | 13.6    | 2.8     | 21.2    | 1.9            | 1.6            | 1.4            | 2.3            | 2.2            | 2.1            |
| DF      | 5       | 8.44    | 5.7     | 11      | 1.6            | 1.4            | 1.2            | 1.8            | 2              | 2.2            |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100% WH =western hemlock; GF =grand fir; DF =Douglas-fir

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

## Tango Creek

The Tango Creek plots were established in 2003 on the Priest Lake Ranger District, IPNF. In Tango Creek, both grand fir and hemlock were defoliated, with grand fir defoliation ratings slightly higher than hemlock in 2003 and 2004. Overall defoliation ratings decreased slightly for

hemlock and increased slightly for grand fir from 2003 to 2004.

### Stand Conditions

The Tango Creek plot area is a hemlock-dominated forest (72% TPA) with western red cedar (21% TPA) and grand fir (6% TPA) (Table 16).

**Table 16:** Stand summary information for Tango Creek Defoliation Permanent Plots in 2003.

| Species           | Trees/ Acre | Basal Area | Quadratic Mean Diameter | % Stand Basal Area | % Stand Trees/ Acre |
|-------------------|-------------|------------|-------------------------|--------------------|---------------------|
| Grand Fir         | 9           | 4          | 9                       | 4                  | 6                   |
| Western Red Cedar | 34          | 20         | 12                      | 18                 | 21                  |
| Western Hemlock   | 114         | 86         | 16                      | 78                 | 72                  |
| <b>TOTAL</b>      | <b>157</b>  | <b>110</b> | <b>14</b>               | <b>100</b>         | <b>100</b>          |

Western red cedar and hemlock dominate the regeneration; western white pine is also present (Table 17).

**Table 17:** Stand regeneration trees per acre summary information for Tango Creek Defoliation Permanent Plots in 2003.

| Species            | TPA 00 - 2.9 DBH | TPA 3.0 - 4.9 DBH | TOTAL       |
|--------------------|------------------|-------------------|-------------|
| Western White Pine | 60               | 0                 | 60          |
| Western Red Cedar  | 1230             | 150               | 1380        |
| Western Hemlock    | 1110             | 60                | 1170        |
| <b>TOTAL</b>       | <b>2400</b>      | <b>210</b>        | <b>2610</b> |

### Defoliation Summary

Grand fir defoliation ratings were slightly higher than hemlock defoliation ratings in both 2003 and 2004. Hemlock defoliation ratings

decreased slightly while grand fir defoliation ratings increased from 2003-2004. The top 1/3<sup>rd</sup> of both species tended to be more heavily defoliated than the lower 2/3<sup>rd</sup>s (Table 18).

**Table 18:** Defoliation rating summary for overstory trees in permanent plots along Tango Creek, Priest Lake Ranger District, Idaho Panhandle National Forest 2002-2004.

| Species | # Trees | Avg DBH | Min DBH | Max DBH | 2003 Ratings*  |                |                | 2004 Ratings*  |                |                |
|---------|---------|---------|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |         |         |         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WH      | 51      | 16.0    | 2       | 45      | 4.8            | 4              | 3              | 4.3            | 3.7            | 3.6            |
| GF      | 2       | 9       | 7.9     | 10.1    | 5              | 3.5            | 1.5            | 5              | 4              | 3.5            |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100% WH = western hemlock; GF= grand fir

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

Hemlock was the most significantly defoliated regeneration species (Table 19).

**Table 19:** Defoliation rating summary for regeneration plot trees in permanent plots along Tango Creek, Priest Lake Ranger District, Idaho Panhandle National Forest 2003-2004.

| Species | # Trees | 2003Ratings*   |                |                | 2004 Ratings*  |                |                |
|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WH      | 6       | 4              | 3.5            | 3.3            | 2.6            | 2.5            | 2.5            |
| WP      | 1       | 2              | 1              | 1              | 1              | 1              | 1              |
| WRC     | 9       | 1              | 1              | 1              | 1              | 1              | 1              |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100% WRC = western red cedar; WH = western hemlock; WP= white pine  
<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

**South Fork Gold Creek**

The South Fork Gold Creek plots were established in 2003 on the Priest Lake Ranger District, IPNF. Grand fir defoliation ratings were slightly higher than hemlock defoliation ratings in both 2003 and 2004

**Stand Conditions:**

The South Fork Gold Creek plot area is a hemlock-dominated forest (97% TPA) with an occasional subalpine fir (2% TPA) and western red cedar (1% TPA) (Table 20).

**Table 20:** Stand summary information for South Fork Gold Creek Defoliation Permanent Plots in 2003.

| Species           | Trees/ Acre | Basal Area | Quadratic Mean Diameter | % Stand Basal Area | % Stand Trees/ Acre |
|-------------------|-------------|------------|-------------------------|--------------------|---------------------|
| Subalpine Fir     | 7           | 2          | 7                       | 1                  | 2                   |
| Western Red Cedar | 4           | 14         | 24                      | 8                  | 1                   |
| Western Hemlock   | 357         | 156        | 10                      | 91                 | 97                  |
| <b>TOTAL</b>      | <b>368</b>  | <b>172</b> | <b>10</b>               | <b>100</b>         | <b>100</b>          |

Hemlock dominates the regeneration; followed by western red cedar, subalpine fir, and spruce (Table 21).

**Table 21:** Stand regeneration trees per acre summary information for South Fork Gold Creek Defoliation Permanent Plots in 2003.

| Species           | TPA 00 - 2.9 DBH | TPA 3.0 - 4.9 DBH | TOTAL       |
|-------------------|------------------|-------------------|-------------|
| Subalpine Fir     | 120              | 30                | 150         |
| Spruce            | 30               | 30                | 60          |
| Western Red Cedar | 300              | 0                 | 300         |
| Western Hemlock   | 1830             | 870               | 2700        |
| <b>TOTAL</b>      | <b>2280</b>      | <b>930</b>        | <b>3210</b> |

**Defoliation Summary**

Subalpine fir defoliation ratings were slightly higher than hemlock defoliation ratings in 2003

but not 2004. The top 1/3<sup>rd</sup> of both species tended to be more heavily defoliated than the lower 2/3<sup>rd</sup>s (Table 22).

**Table 22:** Defoliation rating summary for overstory trees in permanent plots along the South Fork Gold Creek, Priest Lake Ranger District, Idaho Panhandle National Forest 2002-2004.

| Species | # Trees | Avg DBH | Min DBH | Max DBH | 2003Ratings*   |                |                | 2004 Ratings*  |                |                |
|---------|---------|---------|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |         |         |         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WH      | 126     | 10.2    | 2       | 47.4    | 3.2            | 2.3            | 1.8            | 4              | 3.4            | 3.1            |
| SAF     | 3       | 4.4     | 2.3     | 7.2     | 3.3            | 2.7            | 1.3            | 3.3            | 2.7            | 2.7            |
| ES      | 1       | 3.1     | 3.1     | 3.1     | 1              | 1              | 1              | 1              | 1              | 1              |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100% WH = western hemlock; SAF= subalpine fir; ES= Engelmann spruce

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown

Hemlock was the most significantly defoliated regeneration species in 2003, however subalpine fir and Engelmann spruce regeneration was more significantly defoliated than hemlock in 2004 (Table 23).

**Table 23:** Defoliation rating summary for regeneration plot trees in permanent plots along South Fork Gold Creek, Priest Lake Ranger District, Idaho Panhandle National Forest 2003-2004.

| Species | # Trees | 2003Ratings*   |                |                | 2004 Ratings*  |                |                |
|---------|---------|----------------|----------------|----------------|----------------|----------------|----------------|
|         |         | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> | T <sup>1</sup> | M <sup>2</sup> | B <sup>3</sup> |
| WH      | 11      | 1.45           | 1.36           | 1.2            | 3              | 3              | 2.9            |
| SAF     | 1       | 1              | 1              | 1              | 5              | 5              | 5              |
| WRC     | 2       | 1              | 1              | 1              | 1              | 1              | 1              |
| ES      | 1       | 1              | 1              | 1              | 5              | 5              | 5              |

\* Defoliation Ratings based upon Twardus (1985): 1= 0%, 2= 1-25%, 3= 26-50%, 4= 51-75%, 5=76-99%, 6= 100%

WRC = western red cedar; WH = western hemlock; SAF= subalpine fir, ES= Engelmann spruce

<sup>1</sup>T = Top 1/3<sup>rd</sup> of crown      <sup>2</sup>M= Middle 1/3<sup>rd</sup> of crown      <sup>3</sup>B= Bottom 1/3<sup>rd</sup> of crown