

Isaac Gordin  
NRC 534 - Forest Measurements  
12/12/2022

### Final Forest Inventory Report

This forest inventory report is on the Mount Warner forest conservation area. It is located in Hadley, Massachusetts. Hadley is located in western Massachusetts in the Connecticut River Valley. Mount Warner is owned by The Trustees of Reservations. The property is 153.5 acres. The forest's highest point is Mount Warner at 516 feet. The forest consists of hemlock-hardwood stands and pine-hardwood stands. The land history consists of native americans, colonial settlers, and modern day use. The native american land use was by the Archaic Indians, Abinaki tribe, and then the Norwottuck tribe. There was evidence of colonial land use from a well and barbed wire. (Boehmer et. al, 2011) The modern day use has consisted of recreational hiking trails.

To determine what the forest property consisted of, there was an inventory taken. This forest sampling inventory consisted of 60 forest plots, with each plot having subplots for regeneration data, and there were transects to determine down woody material. The plots were laid in a systematic grid. 14 plots were in pine hardwood stands and 46 plots were in hemlock hardwood stands. The plots were variable radius plots with a basal area factor of 20. The regeneration subplots were fixed area plots with a size of 1/1000 acre. The down woody material transects had a length of 325 feet. The variables measured in the overstory plots were: species, diameter at breast height, height, volume, and product class. The variables measured in the regeneration plots were: species, number of seeds, and number of saplings. The variables measured in the downed woody material transects were: species, upper diameter, lower diameter, length, and decay class. This inventory will meet the inventory objectives by determining the volume of the forest and the product class of individual trees. The regeneration objectives were met by establishing subplots and determining the seed count and sapling count. These values were then put on a per acre scale seen in table 5. The objective of the deadwood was met by the down woody material transects. Table 6 and table 7 report down woody material measurements.

The results of the forest inventory analysis shows averages of basal area, trees, and volume on a per acre scale separated by stand. This is shown in table 1. These results show that the forest is fully stocked. (Leak et al., 2014. Silvicultural Guide for Northern Hardwoods in the Northeast.) This shows that the forest has reached a high average diameter breast height and there is a low tree per acre count with a high basal area per acre value. This forest has not been rigorously managed allowing the trees to grow and have a natural thinning process. This forest has a diversity of different tree species, shown in table 3. The hemlock hardwood stand is dominated by eastern hemlock (*Tsuga canadensis*) trees, sweet birch (*Betula lenta*), and northern red oak (*Quercus rubra*). The pine hardwood stand is dominated by sweet birch (*Betula lenta*), eastern white pine (*Pinus strobus*), northern red oak (*Quercus rubra*), and red maple (*Acer*

*rubrum*). If the owners decide to harvest the forest they will find a high amount of hardwood sawtimber which would result in high profits (table 4). Shown in the figures 1 and 2 there is a diameter distribution chart. These figures show the difference in diameters of the pine hardwood and hemlock hardwood stand. The pine hardwood stand's distribution trends to the smaller side more so than the hemlock hardwood stand. The evenness in the hemlock hardwood stand shows that the stand is even aged. The overstory tells a lot of information about the state of the forest, but the regeneration and down woody material show another aspect of the forest.

The regeneration data shows what new plants are growing and the impacts of deer browse. Table 5 shows the number of seedlings and saplings per acre by species and stand. There is concern of oak and hickory regeneration. In the hemlock hardwood stand there are lots of hickory and oak seeds. In the pine hardwood stand there are less oak hickory seeds. Table 6, 7, and 8 discuss the status of dead wood in the forest. In the hemlock hardwood stand there is significantly more dead woody material down on the ground per acre and more standing dead wood per acre. This is due to the growth habits of hemlocks versus pines. The hemlocks succeed in shady environments and have slow growth. Whereas the pines grow fast and thrive in open light environments.

Bibliography:

J. Boehmer, K. DiNardo, L. Gagnon, E. Kells, R. Vieira, (2011) Mount Warner Resource Inventory & Stewardship Plan, [blogs.umass.edu](https://blogs.umass.edu)

M. Itter, (2022) Mt. Warner Inventory Protocol

W. Leak, M. Yamasaki, R. Holleran, (2014) Silvicultural Guide for Northern Hardwoods in the Northeast, USDA

<https://thetrustees.org/place/mount-warner/>

Table 1 reports the mean basal area per acre, mean trees per acre, and mean volume per acre with 95% confidence intervals by stand.

**Table 1:**

<b>Stand</b>	<b>Mean Basal Area per Acre (square feet) and 95% Confidence Interval</b>	<b>Mean Trees per Acre (trees) and 95% Confidence Interval</b>	<b>Mean Volume per Acre (cubic feet) and 95% Confidence Interval</b>
Hemlock-Hardwoods	149.1, 135.7 - 162.6	151.5, 120.7 - 182.3	14313.5, 12994.0 - 15632.8
Pine-Hardwoods	152.9, 127.0 - 178.7	178.9, 113.6 - 244.2	14311.9, 11121.2 - 17502.7

Table 2 reports the stocking of the stands.

**Table 2:**

<b>Stand</b>	<b>Stocking</b>
Hemlock-Hardwoods	Fully Stocked
Pine-Hardwoods	Fully Stocked

Table 3 reports the mean basal area per acre and mean volume per acre with 95% confidence intervals for each tree species by stand.

**Table 3:**

<b>Stand</b>	<b>Species</b>	<b>Mean Basal Area per Acre (square feet) and 95% Confidence Interval</b>	<b>Mean Volume per Acre (cubic feet) and 95% Confidence Interval</b>
Hemlock-Hardwoods	<i>Fagus grandifolia</i>	0.9, -.35 - 2.1	165.9, -77.9 - 409.8
Hemlock-Hardwoods	<i>Quercus velutina</i>	7.0, 1.1 - 12.9	663.8, 75.0 - 1252.6
Hemlock-Hardwoods	<i>Tsuga canadensis</i>	47.04, 34.8 - 59.1	3589.3, 2400.5 - 4778.1
Hemlock-Hardwoods	<i>Pinus strobus</i>	10.4, 5.6 - 15.2	995.7, 424.8 - 1566.5
Hemlock-Hardwoods	<i>Carya tomentosa</i>	0	0
Hemlock-Hardwoods	<i>Quercus rubra</i>	19.6, 13.1 - 26.0	2426.7, 1623.2 - 3230.2
Hemlock-Hardwoods	<i>Carya glabra</i>	7.8, 2.7 - 12.9	886.7, 275.5 - 1498.0
Hemlock-Hardwoods	<i>Acer rubrum</i>	13.0, 7.7 - 18.4	1311.1, 642.9 - 1979.3
Hemlock-Hardwoods	<i>Sassafras albidum</i>	0.4, -.4 - 1.3	NA
Hemlock-Hardwoods	<i>Quercus coccinea</i>	1.3, -.6 - 3.2	201.4, -102.4 - 505.2

Hemlock-Hardwoods	<i>Carya ovata</i>	0.4, -0.4 - 1.3	50.7, -51.5 - 152.9
Hemlock-Hardwoods	<i>Acer saccharum</i>	0.9, -0.4 - 2.1	52.6, -53.3 - 158.5
Hemlock-Hardwoods	<i>Betula lenta</i>	33.5, 20.6 - 46.3	3297.8, 1936.5 - 4659.1
	<i>Fraxinus</i>		
Hemlock-Hardwoods	<i>americana</i>	0.4, -0.4 - 1.3	64.5, -65.4 - 194.4
Hemlock-Hardwoods	<i>Quercus alba</i>	6.5, 2.0 - 11.0	607.2, 138.7 - 1075.7
Pine-Hardwoods	<i>Fagus grandifolia</i>	2.9, -1.3 - 7.1	205.6, -238.6 - 649.9
Pine-Hardwoods	<i>Quercus velutina</i>	14.3, -5.7 - 34.3	1080.8, -276.4 - 2438
Pine-Hardwoods	<i>Tsuga canadensis</i>	2.9, -1.3 - 7.0	285, -137.5 - 707.6
Pine-Hardwoods	<i>Pinus strobus</i>	32.9, 12.3 - 53.4	3757.9, 805.8 - 6710.1
Pine-Hardwoods	<i>Carya tomentosa</i>	1.4, -1.7 - 4.5	205.6, -238.5 - 649.6
Pine-Hardwoods	<i>Quercus rubra</i>	15.7, 2.8 - 28.7	2135.8, 326.4 - 3945.2
Pine-Hardwoods	<i>Carya glabra</i>	7.1, 5.3 - 19.6	824.1, -630.5 - 2278.6
Pine-Hardwoods	<i>Acer rubrum</i>	15.7, 6.5 - 25.0	1518.7, 479 - 2558.4
Pine-Hardwoods	<i>Sassafras albidum</i>	0	0
Pine-Hardwoods	<i>Quercus coccinea</i>	0	0
Pine-Hardwoods	<i>Carya ovata</i>	0	0
Pine-Hardwoods	<i>Acer saccharum</i>	1.4, -1.7 - 4.5	306, -355.1 - 967.1
Pine-Hardwoods	<i>Betula lenta</i>	52.9, 26.6 - 79.1	3216.4, 685.6 - 5747.2
	<i>Fraxinus</i>		
Pine-Hardwoods	<i>americana</i>	0	0
Pine-Hardwoods	<i>Quercus alba</i>	5.7, -1.3 - 12.8	776, -298.9 - 1850.8

Table 4 reports the total sum of volume with 95% confidence intervals by product class by stand.

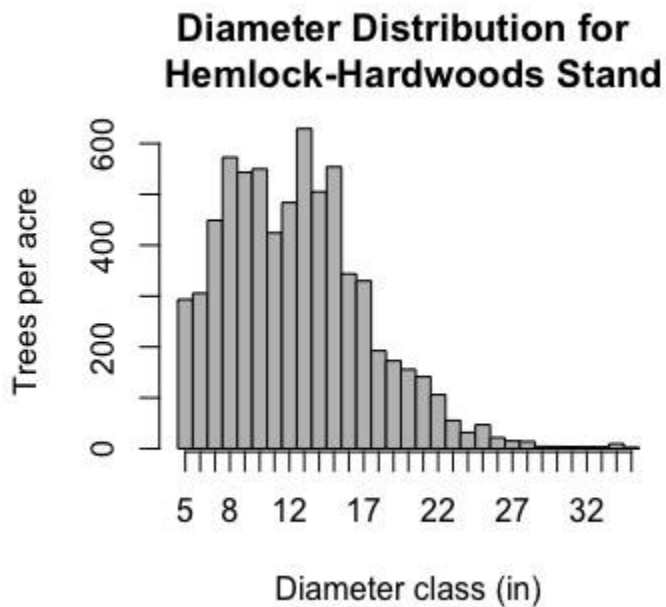
**Table 4:**

Stand	Product	Total Volume(cubic feet) and 95% confidence intervals
Hemlock-Hardwoods	Firewood	1819.9, 1804.1 - 1835.7
Hemlock-Hardwoods	HW Sawtimber	39934.3, 39902.4 - 39966.2
Hemlock-Hardwoods	Non-merchantable	0
Hemlock-Hardwoods	Snag	0
Hemlock-Hardwoods	SW Sawtimber	21816, 21776.8 - 21855.2
Pine-Hardwoods	Firewood	492.7, 416.4 - 569.0
Pine-Hardwoods	HW Sawtimber	21024.6, 20770.3 - 21278.9
Pine-Hardwoods	Non-merchantable	0
Pine-Hardwoods	Snag	0

Pine-Hardwoods	SW Sawtimber	8098, 7973.5 - 8222.5
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Figures 1 and 2 report the diameter distribution of overstory trees by stand.

**Figure 1:**



**Figure 2:**

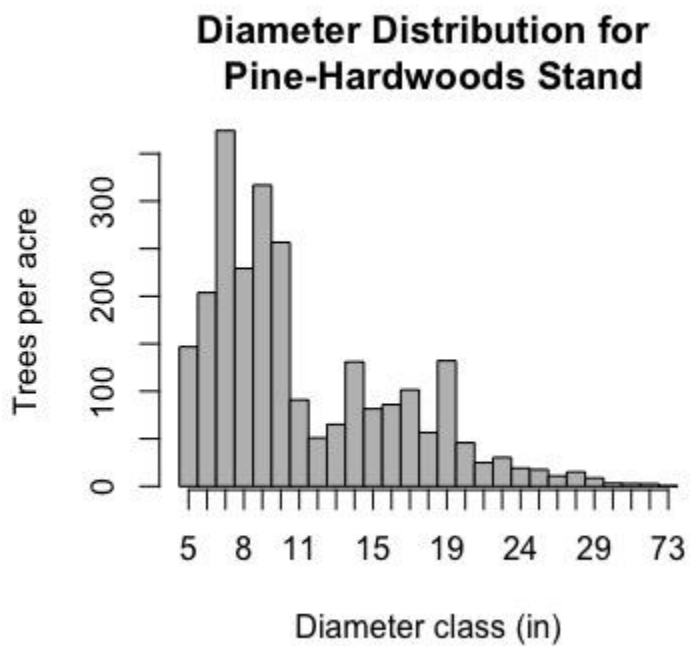


Table 5 reports the seedlings and saplings per acre with 95% confidence intervals for species by stand.

**Table 5:**

<b>Stand</b>	<b>Species</b>	<b>Seedlings per Acre and 95% Confidence Intervals</b>	<b>Saplings per Acre and 95% Confidence Intervals</b>
Hemlock-Hardwoods	<i>Fagus grandifolia</i>	333.3, -1100.9 - 1767.6	666.7, -2201.8 - 3535.1
Hemlock-Hardwoods	<i>Carpinus caroliniana</i>	1666.7, -5504.4 - 8837.8	0
Hemlock-Hardwoods	<i>Betula spp.</i>	1000.0, -3302.7 - 5302.7	0
Hemlock-Hardwoods	<i>Betula lenta</i>	14000.0, -37631.8 - 65631.8	1000.0, -1484.1 - 3484.1
Hemlock-Hardwoods	<i>Quercus velutina</i>	0	0
Hemlock-Hardwoods	<i>Tsuga canadensis</i>	20000.0, -53145.1 - 93145.1	3333.3, -461.2 - 7127.9
Hemlock-Hardwoods	<i>Pinus strobus</i>	0	0
Hemlock-Hardwoods	<i>Acer spp.</i>	17000.0, -22978.4 - 56978.4	0
Hemlock-Hardwoods	<i>Kalmia latifolia</i>	3666.7, -5738.1 - 13071.5	333.3, -1100.9 - 1767.6
Hemlock-Hardwoods	<i>Quercus rubra</i>	3333.3, -5390.7 - 12057.3	0
Hemlock-Hardwoods	<i>Quercus spp.</i>	1000.0, 1000.0 - 1000.0	0
Hemlock-Hardwoods	<i>Carya glabra</i>	5333.3, -7169.9 - 17836.6	1333.3, -100.9 - 2767.6
Hemlock-Hardwoods	<i>Acer rubrum</i>	11000.0, 1063.4 - 20936.6	666.7, -2201.8 - 3535.1
Hemlock-Hardwoods	<i>Sassafras albidum</i>	666.7, -2201.8 - 3535.1	0
Hemlock-Hardwoods	<i>Carya ovata</i>	1333.3, -2461.2 - 5127.9	0
Hemlock-Hardwoods	Shrub species	0	2666.7, -3070.2 - 8403.5
Hemlock-Hardwoods	<i>Acer pennsylvanicum</i>	3333.3, -2918.3 - 9584.9	1000.0, -3302.7 - 5302.7
Hemlock-Hardwoods	<i>Acer saccharum</i>	5666.7, -584.9 - 11918.3	1666.7, 232.4 - 3100.9
Hemlock-Hardwoods	<i>Unknown</i>	17333.3, -637.4 - 35304.0	1000.0, -1484.1 - 3484.1
Hemlock-Hardwoods	<i>Fraxinus americana</i>	1000.0, -1484.1 - 3484.1	0
Hemlock-Hardwoods	<i>Quercus alba</i>	1666.7, -5504.4 - 8837.8	333.3, -1100.9 - 1767.6
Pine-Hardwoods	<i>Fagus grandifolia</i>	0	0
Pine-Hardwoods	<i>Carpinus caroliniana</i>	0	0
Pine-Hardwoods	<i>Betula spp.</i>	0	0
Pine-Hardwoods	<i>Betula lenta</i>	3666.7, -127.9 - 7461.2	2000,

			-6605.3 - 10605.3
Pine-Hardwoods	<i>Quercus velutina</i>	0	333.3, -1100.9 - 1767.6
Pine-Hardwoods	<i>Tsuga canadensis</i>	0	333.3, -1100.9 - 1767.6
Pine-Hardwoods	<i>Pinus strobus</i>	2666.7, -2504.5 - 7837.8	1333.3, -1535 - 4201.8
Pine-Hardwoods	<i>Acer spp.</i>	0	0
Pine-Hardwoods	<i>Kalmia latifolia</i>	0	0
Pine-Hardwoods	<i>Quercus rubra</i>	666.7, -2201.8 - 3535.1	666.7, -2201.8 - 3535.1
Pine-Hardwoods	<i>Quercus spp.</i>	0	333.3, -1100.9 - 1767.6
Pine-Hardwoods	<i>Carya glabra</i>	0	0
Pine-Hardwoods	<i>Acer rubrum</i>	4666.7, -4378.1 - 14071.5	2333.3, -5652.1 - 10318.7
Pine-Hardwoods	<i>Sassafras albidum</i>	0	0
Pine-Hardwoods	<i>Carya ovata</i>	0	0
Pine-Hardwoods	Shrub species	0	0
Pine-Hardwoods	<i>Acer pennsylvanicum</i>	0	0
Pine-Hardwoods	<i>Acer saccharum</i>	0	0
Pine-Hardwoods	<i>Unknown</i>	2333.3, -535.1 - 5201.8	1000.0, -1484.1 - 3484.1
Pine-Hardwoods	<i>Fraxinus americana</i>	333.3, -1100.9 - 1767.6	0
Pine-Hardwoods	<i>Quercus alba</i>	0	0

Table 6 reports the volume per acre of downed woody material per acre by decay class for each stand.

**Table 6:**

Stand	Decay Class	Volume per Acre(cubic feet)
Hemlock-Hardwoods	1	33.2
Hemlock-Hardwoods	2	29.4
Hemlock-Hardwoods	3	37
Hemlock-Hardwoods	4	24.4
Hemlock-Hardwoods	5	6.6
Pine-Hardwoods	1	6.2
Pine-Hardwoods	2	4.8
Pine-Hardwoods	3	12
Pine-Hardwoods	4	10.5
Pine-Hardwoods	5	2.6

Table 7 reports the total amount of downed woody material for each stand



**Table 7:**

Stand	Downed Woody Material (cubic feet)
Hemlock-Hardwoods	856.7
Pine-Hardwoods	199.6

Table 8 reports the average trees per acre and basal area per acre with 95% confidence intervals of snags by stand.

**Table 8:**

Stand	Basal Area per Acre (square feet)	Trees per Acre
Hemlock-Hardwoods	8.3, 4.0 - 12.5	6.3, 3.0 - 9.7
Pine-Hardwoods	1.4, -1.7 - 4.5	0.7, -0.8 - 2.3

R Appendix:

## Isaac Gordin

## NRC 534 - Forest measurements

## Final Project: Forest Inventory Report

## Due 12/12 @ 10:10 am

# Load required R packages

library(plyr)

library(plotrix)

library("writexl")

# Load data

os\_dat <- read.table("overstory\_dat.csv", header = TRUE, sep = ",")

regen\_dat <- read.table("regen\_dat.csv", header = TRUE, sep = ",")

dwm\_dat <- read.table("dwm\_dat.csv", header = TRUE, sep = ",")

#The Basal Area Factor used is 20

baf <- 20

#Define the forester's constant

fc <- pi/(4\*144)

# Define function to find t-value - COPIED FROM CLASS NOTES

find\_t <- function(conf, n\_plots){

qt(1 - ((1-(conf/100))/2), n\_plots - 1)

}

#Add Basal Area to os\_dat

os\_dat\$ba <- ((os\_dat\$Dbh)^2) \* fc

#Add expansion factor to os\_dat

os\_dat\$ef <- baf/os\_dat\$ba

ph <- os\_dat[os\_dat\$Stand == "pine-hardwoods",]

hh <- os\_dat[os\_dat\$Stand == "hemlock-hardwoods",]

#Number of plots for respective stands, pine hardwood and hemlock hardwood

phPlots <- 14

hhPlots <- 46

#Using our defined function we can determine these tStar 95% confidence interval values

```
ph_tStar <- find_t(95, phPlots)
```

```
hh_tStar <- find_t(95, hhPlots)
```

#NUMBER 1

#Define BAA, TPA, VPA values for the overstory data

```
osDatTable <- ddply(os_dat, .(Stand, PlotID), summarize, tpa = sum(ef),  
  baa = sum(ef*ba), vpa = (sum(ef*Vol, na.rm = TRUE)))
```

#Averaging BAA, VPA, TPA values and generating 95% confidence interval values

```
num1 <- ddply(osDatTable, .(Stand), summarize, meanBAA = mean(baa), meanTPA =  
  mean(tpa), meanVPA = mean(vpa),  
  cilBAA = mean(baa) + -1*find_t(95, length(Stand))*std.error(baa),  
  ciuBAA = mean(baa) + 1*find_t(95, length(Stand))*std.error(baa),  
  cilVPA = mean(vpa) + -1*find_t(95, length(Stand))*std.error(vpa),  
  ciuVPA = mean(vpa) + 1*find_t(95, length(Stand))*std.error(vpa),  
  cilTPA = mean(tpa) + -1*find_t(95, length(Stand))*std.error(tpa),  
  ciuTPA = mean(tpa) + 1*find_t(95, length(Stand))*std.error(tpa))
```

#Numbers 3 & 4

```
osDatTableSpHH <- ddply(hh, .(PlotID, Species), summarize, baa = sum(ef*ba),  
  vpa = (sum(ef*Vol, na.rm = TRUE)), .drop = FALSE)  
osDatTableSpPH <- ddply(ph, .(PlotID, Species), summarize, baa = sum(ef*ba),  
  vpa = (sum(ef*Vol, na.rm = TRUE)), .drop = FALSE)
```

#Averaging BAA, VPA, values and generating 95% confidence interval values

```
num34HH <- ddply(osDatTableSpHH, .(Species), summarize,  
  meanBAA = round(mean(baa),2), meanVPA = round(mean(vpa),2),  
  cilBAA = mean(baa) + -1*find_t(95, hhPlots)*std.error(baa),  
  ciuBAA = mean(baa) + 1*find_t(95, hhPlots)*std.error(baa),  
  cilVPA = mean(vpa) + -1*find_t(95, hhPlots)*std.error(vpa),  
  ciuVPA = mean(vpa) + 1*find_t(95, hhPlots)*std.error(vpa))
```

#Averaging BAA, VPA, values and generating 95% confidence interval values

```
num34PH <- ddply(osDatTableSpPH, .(Species), summarize,  
  meanBAA = round(mean(baa),2), meanVPA = round(mean(vpa),2),  
  cilBAA = mean(baa) + -1*find_t(95, phPlots)*std.error(baa),  
  ciuBAA = mean(baa) + 1*find_t(95, phPlots)*std.error(baa),  
  cilVPA = mean(vpa) + -1*find_t(95, phPlots)*std.error(vpa),  
  ciuVPA = mean(vpa) + 1*find_t(95, phPlots)*std.error(vpa))
```

```
#NUMBER 5 total volume and 95 percent confidence intervals by product class for each stand
osDatTablVol <- ddply(os_dat, .(Stand, Product), summarize, vol = Vol, .drop = FALSE)
```

```
#Summing volumes and calculating confidence intervals - do i need to organize based on plot
num5 <- ddply(osDatTablVol, .(Stand, Product), summarize, totVol = sum(vol, na.rm = TRUE),
  cilVol = sum(vol, na.rm = TRUE) + -1*find_t(95, length(Stand))*std.error(vol, na.rm =
TRUE),
  ciuVol = sum(vol, na.rm = TRUE) + 1*find_t(95, length(Stand))*std.error(vol, na.rm =
TRUE))
```

```
#NUMBER 6, diameter distribution figures per stand
phDiamTable <- ddply(ph, .(Dbh), summarize, tpa = sum(ef))
barplot(phDiamTable$tpa, space = 0, names.arg = phDiamTable$Dbh,
  main = "Diameter Distribution for \n Pine-Hardwoods Stand",
  xlab = "Diameter class (in)", ylab = "Trees per acre",axis.lty = 1)
```

```
hhDiamTable <- ddply(hh, .(Dbh), summarize, tpa = sum(ef))
barplot(hhDiamTable$tpa, space = 0, names.arg = hhDiamTable$Dbh,
  main = "Diameter Distribution for \n Hemlock-Hardwoods Stand",
  xlab = "Diameter class (in)", ylab = "Trees per acre",axis.lty = 1)
```

```
#NUMBER 7 seedlings and saplings per acre and 95% CI's
phRegen <- regen_dat[regen_dat$Stand == "pine-hardwoods",]
hhRegen <- regen_dat[regen_dat$Stand == "hemlock-hardwoods",]
regEF = 1000 #plot = 1/1000 acre
regenDatTabPH <- ddply(phRegen, .(Subplot, Species), summarize,
  SPA = sum(n_seed * regEF),
  SaPA = sum(n_sap * regEF), .drop = FALSE)
regenDatTabHH <- ddply(hhRegen, .(Subplot, Species), summarize,
  SPA = sum(n_seed * regEF),
  SaPA = sum(n_sap * regEF), .drop = FALSE)
```

```
#Averaging determing seedlings and saplings per acre with 95% CI intervals
rgPH <- ddply(regenDatTabPH, .(Species), summarize, spa = mean(SPA, na.rm = TRUE), sapa =
mean(SaPA, na.rm = TRUE),
  cilSeed = mean(SPA) + -1*find_t(95, length(Subplot))*std.error(SPA),
  ciuSeed = mean(SPA) + 1*find_t(95, length(Subplot))*std.error(SPA),
  cilSap = mean(SaPA) + -1*find_t(95, length(Subplot))*std.error(SaPA),
  ciuSap = mean(SaPA) + 1*find_t(95, length(Subplot))*std.error(SaPA))
```

```

rgHH <- ddply(regenDatTabHH, .(Species), summarize, spa = mean(SPA, na.rm = TRUE), sapa
= mean(SaPA, na.rm = TRUE),
  cilSeed = mean(SPA) + -1*find_t(95, length(Subplot))*std.error(SPA),
  ciuSeed = mean(SPA) + 1*find_t(95, length(Subplot))*std.error(SPA),
  cilSap = mean(SaPA) + -1*find_t(95, length(Subplot))*std.error(SaPA),
  ciuSap = mean(SaPA) + 1*find_t(95, length(Subplot))*std.error(SaPA))

#NUMBER 8 DWM per acre by decay class
# Estimate average DWM diameter
dwm_dat$d_bar <- with(dwm_dat, (1/2)*(dl + du))

# Estimate DWM volume (in cubic feet)
dwm_dat$vol <- with(dwm_dat, ((d_bar/2)^2)*pi*length)

# Calculate DWM ratio
dwm_dat$ratio <- with(dwm_dat, vol/(dl + du + 2*length)) #Do i need this line

# Sum ratio by transect and decay class
dwm_trans_dat <- ddply(dwm_dat, .(Stand, TransID, decay_class), summarize, dwm_tot =
sum(ratio), .drop = FALSE)

# Replace NA values with zero (no DWM present along transect)
dwm_trans_dat$dwm_tot[is.na(dwm_trans_dat$dwm_tot)] <- 0

# Area of interest
A <- 43560

# Transect length
L <- 325

# Put volume of DWM on per-acre scale
dwm_trans_dat$VPA <- ((pi*A)/L)*dwm_trans_dat$dwm_tot

# Estimate mean DWM per acre by decay class
DWMTab <- ddply(dwm_trans_dat, .(Stand, decay_class), summarize, vpa =
round(mean(VPA),1))

#9 Total amount of DWM within each stand
ddply(dwm_dat, .(Stand), summarize, totVol = sum(vol))
#10 mean TPA and BAA and corresponding 95 percent confidence intervals of snags by stand.

```

```
osSnagTable <- ddply(os_dat, .(Stand, PlotID, Product), summarize, tpa = sum(ef),  
  baa = sum(ef*ba))
```

```
snagTabPH <- ddply(ph, .(PlotID, Product), summarize, tpa = sum(ef),  
  baa = sum(ef*ba), .drop = FALSE)
```

```
snagTabHH <- ddply(hh, .(PlotID, Product), summarize, tpa = sum(ef),  
  baa = sum(ef*ba), .drop = FALSE)
```

#average baa and tpa with 95 confidence interval

```
ddply(osSnagTable, .(Stand, Product), summarize, meanBAA = mean(baa), meanTPA =  
mean(tpa),
```

```
  cilBAA = mean(baa) + -1*find_t(95, length(Stand))*std.error(baa),
```

```
  ciuBAA = mean(baa) + 1*find_t(95, length(Stand))*std.error(baa),
```

```
  cilTPA = mean(tpa) + -1*find_t(95, length(Stand))*std.error(tpa),
```

```
  ciuTPA = mean(tpa) + 1*find_t(95, length(Stand))*std.error(tpa))
```

```
ddply(snagTabPH, .(Product), summarize, meanBAA = mean(baa), meanTPA = mean(tpa),
```

```
  cilBAA = mean(baa) + -1*find_t(95, phPlots)*std.error(baa),
```

```
  ciuBAA = mean(baa) + 1*find_t(95, phPlots)*std.error(baa),
```

```
  cilTPA = mean(tpa) + -1*find_t(95, phPlots)*std.error(tpa),
```

```
  ciuTPA = mean(tpa) + 1*find_t(95, phPlots)*std.error(tpa))
```

```
ddply(snagTabHH, .(Product), summarize, meanBAA = mean(baa), meanTPA = mean(tpa),
```

```
  cilBAA = mean(baa) + -1*find_t(95, hhPlots)*std.error(baa),
```

```
  ciuBAA = mean(baa) + 1*find_t(95, hhPlots)*std.error(baa),
```

```
  cilTPA = mean(tpa) + -1*find_t(95, hhPlots)*std.error(tpa),
```

```
  ciuTPA = mean(tpa) + 1*find_t(95, hhPlots)*std.error(tpa))
```