Unit 3 -- Stand and Stock Tables

Stand and Stock tables are the traditional way of describing plots of stands. It is very common that they are made from any forest inventory data. Stand tables are a set of variables by diameter classes. Stock tables are a set of variables by species classes. In this unit I will explain how to calculate the variable in a stand and stock tables and several of its uses.

Learning Objectives:

- Learn to calculate trees per acre, basal area, Quadratic mean diameter, cubic foot volume, and board foot volume.
- Learn about the format of Stand tables.
- Learn about the format of Stock tables.
- Learn to make a composition figure.
- Learn to make a diameter distribution figure.

Data Needs:

You will need a minimum on one plot. The plot needs a tree list.

Each tree will have a record with:

- tree species,
- diameter at breast height,
- merchantable or total height,
- plot expansion factor.

These will be explained as the work through the calculations

Stand Table

Table 1. Example of a typical Stand Table, in English units.

Dclasses	n	tpa	ba	Dq	volcf	volbf
5	3	15	2.298653	5.300629	20.31496	0
7	11	55	15.43444	7.172992	236.512	0
9	0	0	0	0	0	0
11	3	15	9.754482	10.91925	120.7631	296.6893
13	2	10	9.598493	13.26593	151.7636	797.7677
15	1	5	6.300639	15.2	128.4909	685.5321
17	1	5	7.156941	16.2	128.5523	679.572
Total	21	105	50.54365	9.394527	786.3969	2459.561

The Stand Table in table 1. organized as 2" **Diameter classes** in the first column, then for each variable the number of trees in that class. The table can be calculated for just the plot but because many people use different plot designs the plot does not make a very good reporting unit. Typically use unit areas, that is, acres in English units and hectares in metric units.

Let's talk about each column. The first column data is left off by some people but I feel it is important to let the reader understand the strength of the sample. The Column labeled "**n**" is the number of sample trees in each size class. Not that for two of the rows the numbers is based on one tree.

The second data column is the **tree per acre** or **tpa.** To get this number you need to know the "**n**" from the previous column and the expansion factor. Expansion factor is a number that for a single tree describes the number of trees represent per unit are in that sample design. In fixed area plots the number is easy to determine. The plot used in table 1. has an expansion factor of 5 the plot is a 1/5th acre plot so each tree represents 5 trees per acre. You will not that in this case the **tpa** column is 5 times the "**n**" column.

The third data column is **basal area per acre** or **ba**. We need to work through several steps here. First the basal area of a tree is:

$$ba = \frac{\pi}{4 * 144} * dbh^2$$

In this case for English units all but the 144 is the area formula were we use diameter instead of the familiar:

$$a = \pi * r^2$$

The 144 is needed to convert from the diameter units, which are inches to the desired units for basal area, which are square feet. Most of the formula collapses to a constant thus yielding:

$$ba = 0.005454154 * dbh^2$$

We now have to take the area in the sample tree and expand it to a per acre basis by multiplying by the expansion factor. Then when summed by group and total provide the basal area per acre in the group and total for the sample.

The fourth data colume is labeled **Quadratic Mean Diameter** or **Dq.** If you remember the **Dq** is the diameter of the tree of average basal area. We use the follow:

$$Dq = \sqrt{\frac{\frac{ba}{tpa}}{0.005454154}}$$

The fifth data column is the cubic foot volume of the trees. A cubic foot is defined as 1' x 1' x 1' and one foot cube. The Volume of a tree is usually calculated by a formula that is a variation of

$$v = b_1 d^2 h$$

Remember a volume of a cylinder is

$$v = d^2h$$

The rest is to account for taper and bark thickness. Cubic volume is usually calculated for all trees regardless of size. Once the volume for the tree has been calculated we have to expand the per tree volume to a volume per acre. Then these are summed by group and total.

In North America, we usually include a board foot volume estimate. Most of the rest of the work only uses cubic measures of volume. A board foot is defined as 1"x12"x12" or 1" x 1' x 1'. Given what we said above you might assume that there are 12 board feet in a cubic foot of wood. This is not correct several factors impact the result. First is kerf. Kerf is the space used to allow the saw blade to pass through the wood. Typical kerfs vary from ¼" to 1/8" to 1/16" as might be expected smaller kerfs yield more total board feet for a given amount of cubic feet. Additionally, trees are tapered cylinders not rectangular blocks so some wood is lost in half round (slabs) cut off the outside of the log. Taper further reduces the recoverable part of the log. Recovery rate also changes with the diameter of the log. The net effect is that for most solid trees only about 6-9 board feet are recoverable from cubic feet available in a log.

However, with all this said, the processing of board foot volume is again a process of starting with the volume of the individual tree, expanded to a per acre bases and summed by groups and total. You will note that the volbf diameter classes below 11 are 0. This is because tree less that 10's are considered non-merchantable.

Special Note: when doing these calculations for multiple plots, each plot is a per acre estimate of each value to get the area wide estimate we need to average plot statistics

Stock Table

You will not that the layout of the stock table (see Table 2.) and its variables are the same as the stand table except the rows are tree species or species groups. The calculations are the same except that sum or different groups.

Table 2. Example Stock table for the same plot, in English units

Sclasses	n	tpa	ba	Dq	volcf	volbf
Pine	5	25	5.635777	6.428997	80.96305	0
RedOak	2	10	7.03804	11.35958	135.2619	685.5321
WhiteOak	14	70	37.86983	9.959418	570.172	1774.029
Total	21	105	50.54365	9.394527	786.3969	2459.561

Creating stand and Stock tables in R

Now we will step through the process of using the code provided to make stand and stock tables.

First you will note that the link is for both code and data in one zip file. Download the zip file to a working directory.

Unzip the files

The directory should include:

standtable.R These two functions are the main function for the stand and stock tables.
stocktable.R

dclass.R These are the functions to build the diameter classes or species classes.
spclass.R
sptable.R This functionis used by stock table to convey the species classes to the stocktable function

volume.R This function calcalulated the cubic and board foot volume for the tables.
bat.R This function calculated the basal area per tree.

load.table.R This is a service script that sources all the other files.

p1.R This is the plot data file this plot has data from the follow years.

1957, 1962, 1967, 1972, 1977, 1982, 1987, 1992, 1997, 2002, 2007

Steps

Open R in the working directory and run

```
>source("load.table.R")
```

Your directory should look like this.

```
> ls ()
 [1] "bat"       "d"         "dclass"     "ht"        "p1"
 [6] "spclass"    "sptable"    "standtable" "stocktable" "volume"
```

This function lists the available years in your data file.

```
> names(p1)
 [1] "y57" "y62" "y67" "y72" "y77" "y82" "y87" "y92" "y97" "y02" "y07"
```

Next we list the function to calculate the basal area

```
function( treeplot, BAconstant=0.005454154, expfac=0)
{
# Function to calculate the plot tpa, ba, and dq
# by David R. Larsen, Copyright, December 10, 2010
#
  if( expfac == 0 ){
    bat = BAconstant * treeplot$dbh^2 * treeplot$expfac
  }else{
    bat = BAconstant * treeplot$dbh^2 * expfac
  }
  bat
}
```

And then the function to calculate the tree volume.

```
function( dbh, mht, type="cubic", merchdbh=0 ){
#
# Function to calculate tree volumes from Beers 1964
# by David R. Larsen, Copyright July 19, 2006
#
    if( dbh > merchdbh )
    {
      aa <- (dbh^2 * (dbh + 190))/ 100000
      bb <- (1/100) * (((mht * (168 - mht))/64) + (32/mht) )
      bb[mht<1.0]<-0.0
      cc <- 475 + ( 3 * mht^2)/ 128
      volume <- 0.0
      if( type == "cubic" ){
            volume <- 92 * aa * bb
      }else if( type == "board" ){
            volume <- aa * bb * cc
      }else{
            volume <- aa * bb
      }
    }else{
      volume <- 0.0
    }
    volume
}
```

Note that dbh is assumed to be in inches, mht in feet and type must be “cubic” or “board” or the function will return cords. In the dbh is less than the merchantable limit a 0 volume is returned.

Sptable translated species code in the data into reportable species classes.

```
> sptable
  species      spclass
1       0         Dead
2      10       RedOak
3      11       RedOak
4      12       RedOak
5      13       RedOak
6      20     WhiteOak
7      21     WhiteOak
8      22     WhiteOak
9      23     WhiteOak
10     30         Pine
11     31        Cedar
12     40      Hickory
13     50   OtherMerch
14     51   OtherMerch
15     52   OtherMerch
16     53   OtherMerch
17     54   OtherMerch
18     55   OtherMerch
19     56   OtherMerch
20     57   OtherMerch
21     58   OtherMerch
22     59   OtherMerch
23     60        Maple
24     70       Walnut
25     71       Walnut
26     80 OtherNonMerch
27     81 OtherNonMerch
28     82 OtherNonMerch
29     83 OtherNonMerch
30     84 OtherNonMerch
31     85 OtherNonMerch
32     86 OtherNonMerch
33     87 OtherNonMerch
34     88 OtherNonMerch
35     89 OtherNonMerch
36     90       Cherry
```

37 91 OtherMerch

To run the stocktable you must pass a single plot year combination to the function.

> stocktable(p1$y72,sptable) this version is passing the p1, year 72 to the function and the species table.

```
Stock table
  sclasses  n tpa        ba        Dq     volcf     volbf
1     Pine  5  25  5.635777  6.428997  16.19261   0.0000
2   RedOak  2  10  7.038040 11.359577  27.05238 137.1064
3 WhiteOak 14  70 37.869827  9.959418 114.03439 354.8058
4    Total 21 105 50.543645  9.394527 157.27939 491.9122
```

These number are for the plot only, in the next example the 5 is the expansion factor for the plot.

> stocktable(p1$y72,sptable,5)

```
Stock table
  sclasses  n tpa        ba        Dq     volcf     volbf
1     Pine  5  25  5.635777  6.428997  80.96305    0.0000
2   RedOak  2  10  7.038040 11.359577 135.26191  685.5321
3 WhiteOak 14  70 37.869827  9.959418 570.17197 1774.0290
4    Total 21 105 50.543645  9.394527 786.39693 2459.5611
```

These numbers are the same plot but expanded to a per acre basis.

Figures from stand tables

One very nice feature of these tables is that they make it easy to create diameter distribution figures.

These figures are the trees per acre plot on the Y axis and the diameter classes plotted on the x axis.

We are going to make a script file to hold several repeated commands.

Open file.edit and add the following lines

```
# Script to make a diameter distribution from a standtable
# by David R. Larsen January 31, 2012
#
# Modify the years in these two lines
#
dta=standtable(p1$y72,2,5)
main="Plot 1, 1972"
#
#
xlab="Diameter Classes (in)"
ylab="Trees per acre"
height=dta$tpa[-length(dta$tpa)]
dc.names=(dta$dclasses[-length(dta$tpa)])
bar.color=rep(2,length(dta$tpa)-1)
barplot(height=height,names.arg=dc.names,col=bar.color,xlab=xlab,
  ylab=ylab,main=main)
```

Note to change years you will need to change the year number in the two lines at the top of the script.

```
# Script to make a composition from a stocktable
# bt David R. Larsen January 31, 2012
#
# Modify the years in these two lines
#
dta=stocktable(p1$y72,sptable,5)
main="Plot 1, 1972"
#
#
xlab="Species Classes"
ylab="Trees per acre"
height=dta$tpa[-length(dta$tpa)]
sp.names=(dta$sclasses[-length(dta$tpa)])
bar.color=seq(1,length(dta$tpa)-1,1)
barplot(height=height,names.arg=sp.names,col=bar.color,xlab=xlab,ylab=
  ylab,main=main)
```

Please enter these two scripts and create each of the figure of each year in the data set.