Introduction to Wildland Fire, Fall 2011

Exercise 1: How much energy is there is a pine forest?

We've talked a bit about the energy equivalence of biomass, because fire is a release of stored energy in biomass. So how much energy is stored in ecosystems?

We'll take the example of a stand of ponderosa pines (*P. ponderosa*). For simplicity we will ignore other species that may be present, such as grasses, forbs, shrubs, or other species of trees -- obviously these would all contribute to the total. We will also overlook belowground biomass (which contributes to fire behavior in very different ways). So we want to know how much a ponderosa pine tree weighs aboveground, and then figure out how much energy that represents.

1. One way to estimate mass is through the use of allometric equations, which transform one tree measurement (say, diameter) into another (say, mass in kilograms). A general equation for the mass of a tree (from Jenkins et al. 2004) is:

$$M_a = e^{(B0 + B1 \times \ln \text{dbh})}$$

Where:
M_a = Total aboveground biomass (kg)
dbh = diameter breast height (cm)
B_0 = intercept term
B_1 = scaling (allometric) term
e = base of natural logarithms (~2.718281828)
ln = to take the natural log of a number

For pines, the values of the allometric constants are:
B_0 = - 2.5356
B_1 = 2.4349

Once we have mass, we can convert this to energy (in MJ) using the value (for MJ/kg) given in Lec 1.2.

2. A second way to estimate energy in a forest stand is to use a stand-level estimate of mass. For ponderosa pine forest, one estimate is that a hectare of pine forest has a mass of approximately 100,000 kg.

Your assignment is to estimate the energy content of a hectare of pine forest two different ways, and see if you come up with estimates that are roughly comparable.

1. Estimate the energy content of a hectare of pine trees using the allometric equation and constants in (1) above. You can set up the equation in a series of cells in an Excel worksheet, use R or some other program of your choice, or just solve it with paper and calculator. To do this:
    a. First solve for the mass of a single tree, using the allometric equation and constants given above. You may find it easier to first calculate the term in parenthesis, and the take *e* to that number. Remember the correct order of operations.

b. Multiply out by the number of trees per hectare to get mass per hectare, and then multiply that by the conversion factor for energy per mass (MJ/ kg) to get energy per hectare (of course, you can do these two steps in either order, *si*?). Assume that the dbh of all trees is 31 cm, and that there are 300 trees/ha.

2. Now estimate the same quantity, energy (MJ) per hectare using the stand-level estimate of the mass of a pine forest given in (2), and using the same energy conversion factors.

3. Were the two estimates roughly comparable?

Literature cited:

Jenkins, Jennifer C.; Chojnacky, David C.; Heath, Linda S.; and Birdsey, Richard A. 2004. *Comprehensive database of diameter-based biomass regressions for North American tree species.* Gen. Tech. Rep. NE-319. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 45 p.