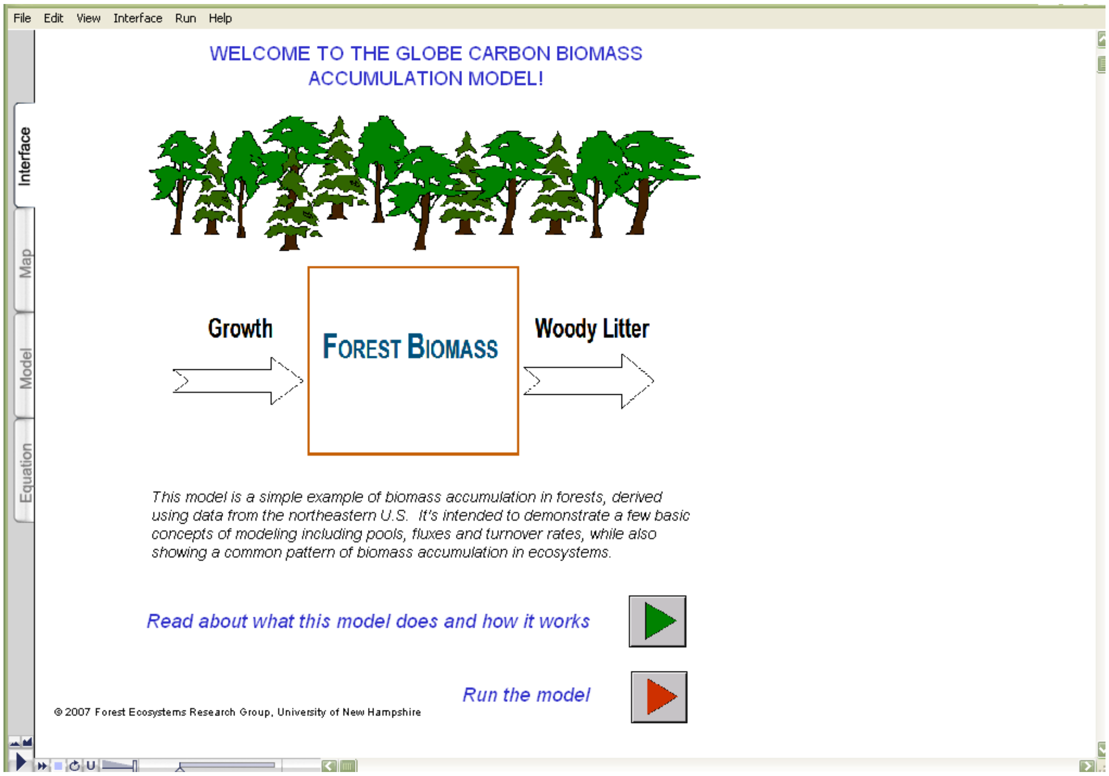
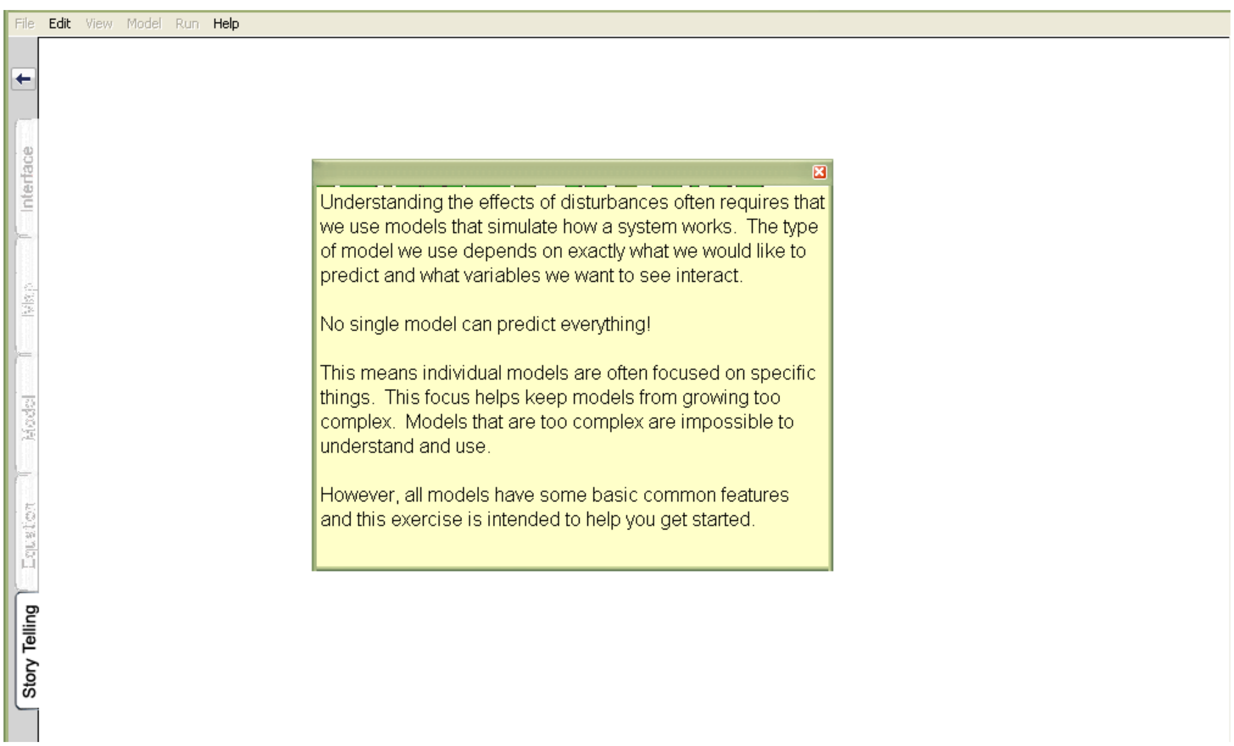
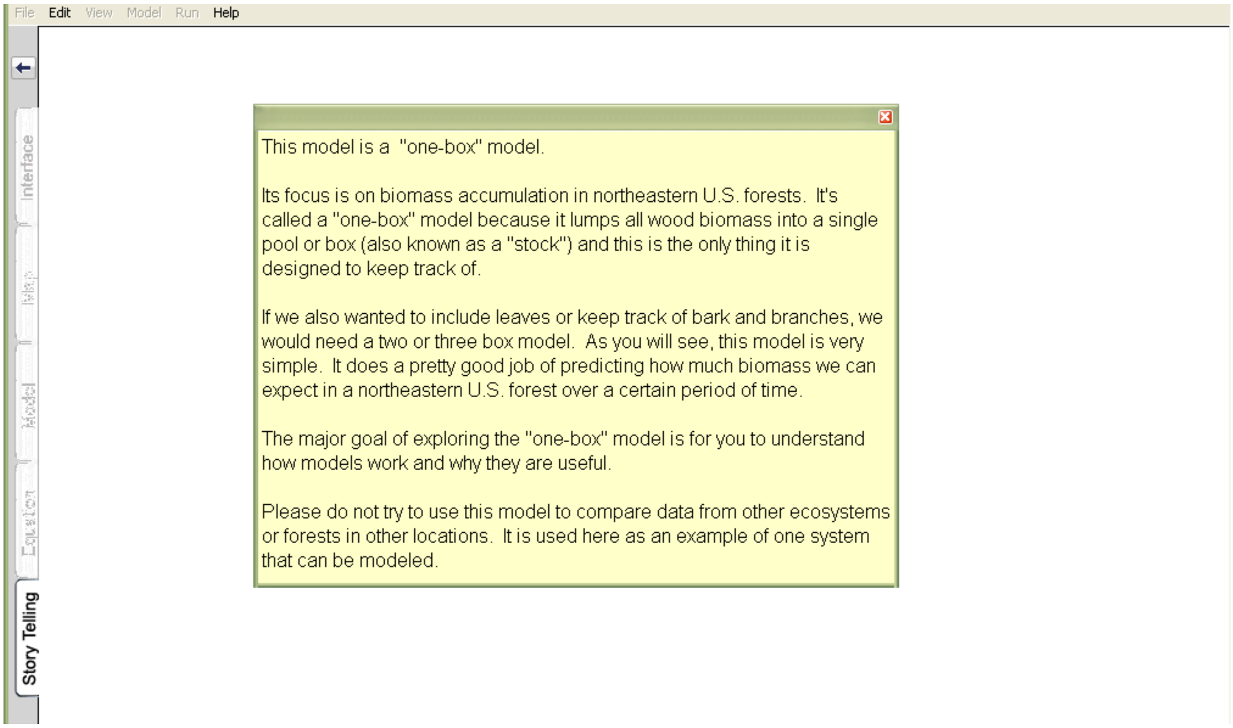
GLOBE Carbon Cycle

1 Box Biomass Accumulation Model
STORY



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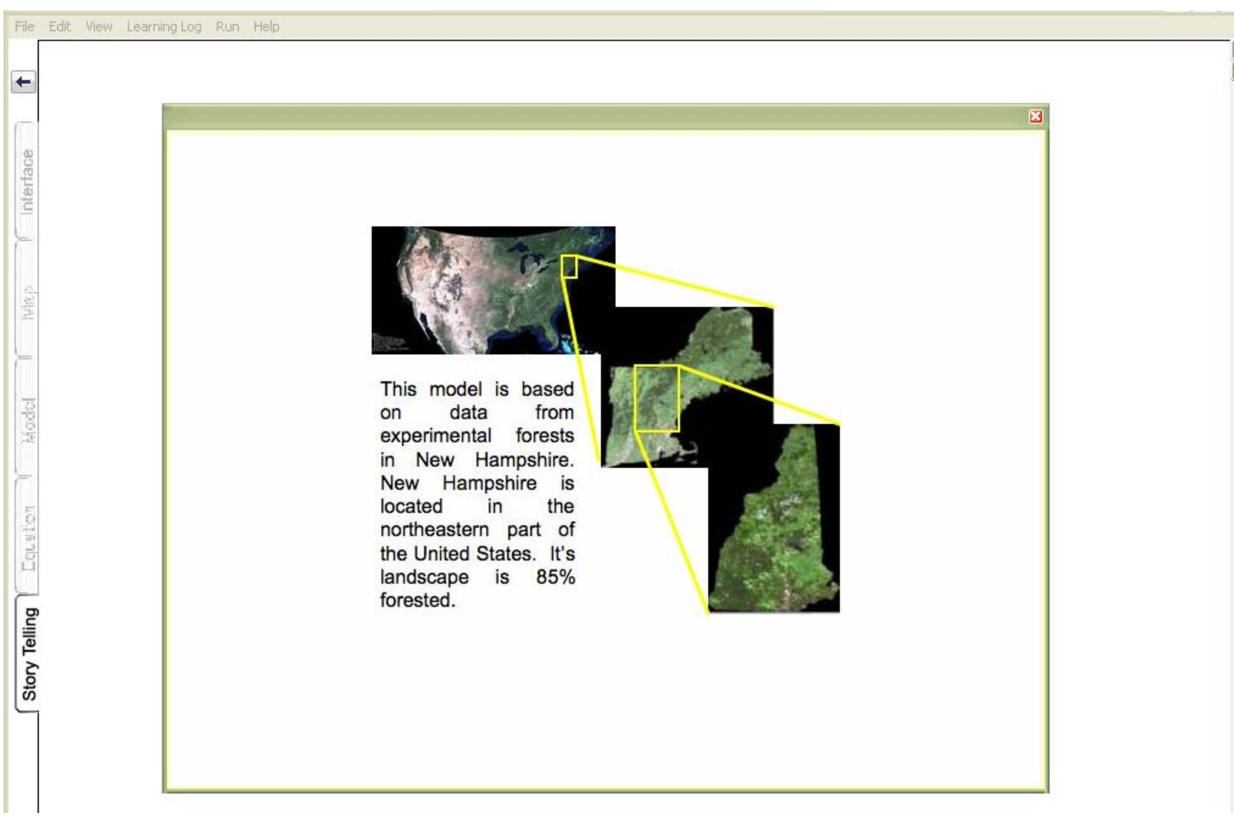
Story Telling
This model is a "one-box" model.
Its focus is on biomass accumulation in northeastern U.S. forests. It's called a "one-box" model because it lumps all wood biomass into a single pool or box (also known as a "stock") and this is the only thing it is designed to keep track of.
If we also wanted to include leaves or keep track of bark and branches, we would need a two or three box model. As you will see, this model is very simple. It does a pretty good job of predicting how much biomass we can expect in a northeastern U.S. forest over a certain period of time.
The major goal of exploring the "one-box" model is for you to understand how models work and why they are useful.
Please do not try to use this model to compare data from other ecosystems or forests in other locations. It is used here as an example of one system that can be modeled.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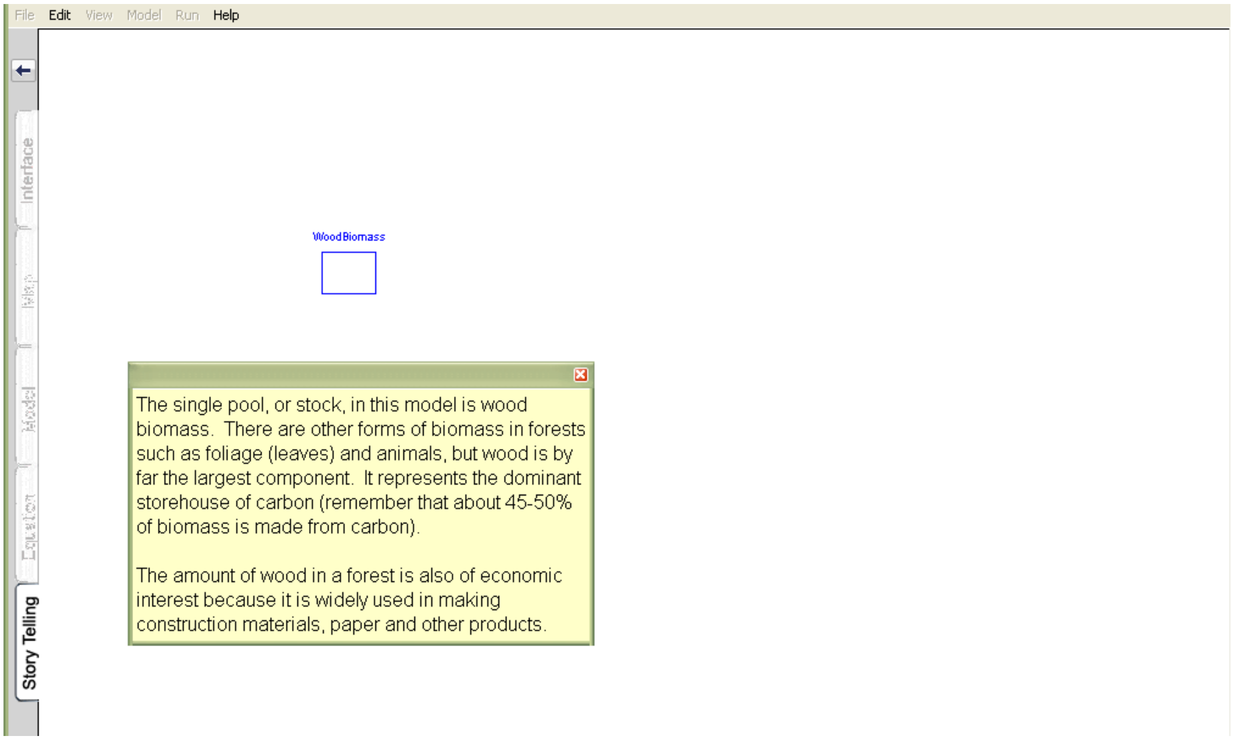
This model is based on data from experimental forests in New Hampshire. New Hampshire is located in the northeastern part of the United States. It's landscape is 85% forested.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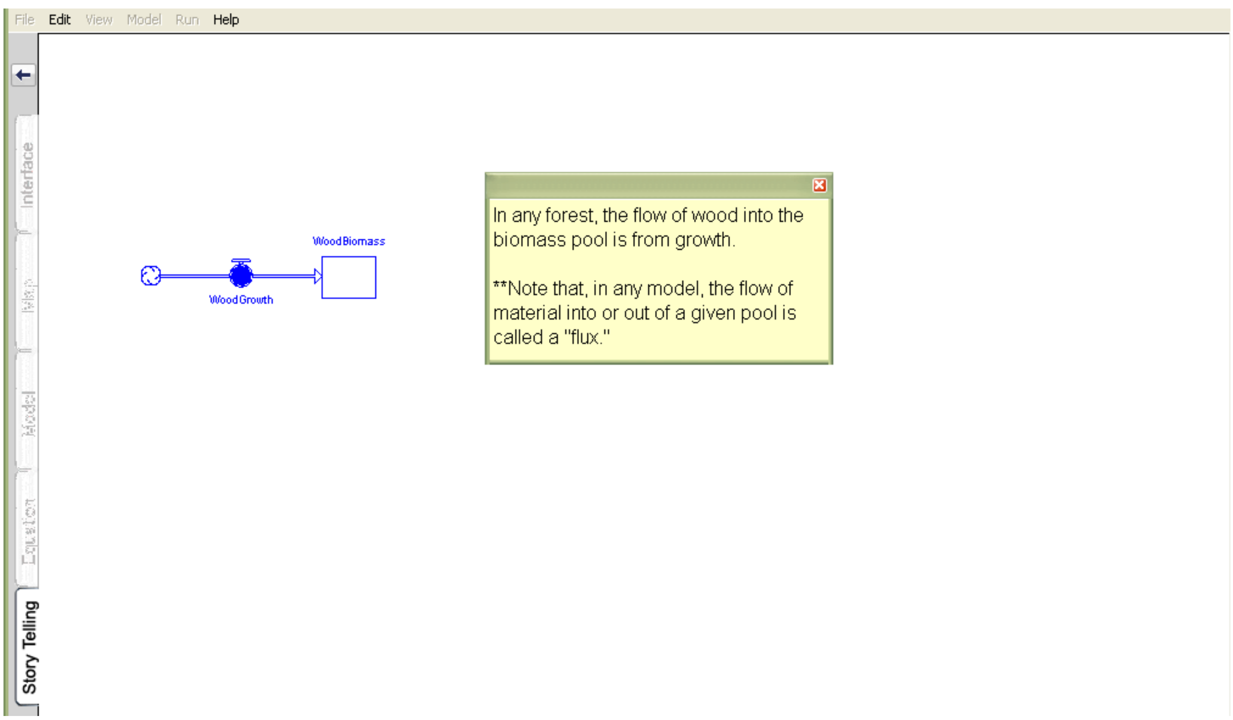
WoodBiomass
The single pool, or stock, in this model is wood biomass. There are other forms of biomass in forests such as foliage (leaves) and animals, but wood is by far the largest component. It represents the dominant storehouse of carbon (remember that about 45-50% of biomass is made from carbon).
The amount of wood in a forest is also of economic interest because it is widely used in making construction materials, paper and other products.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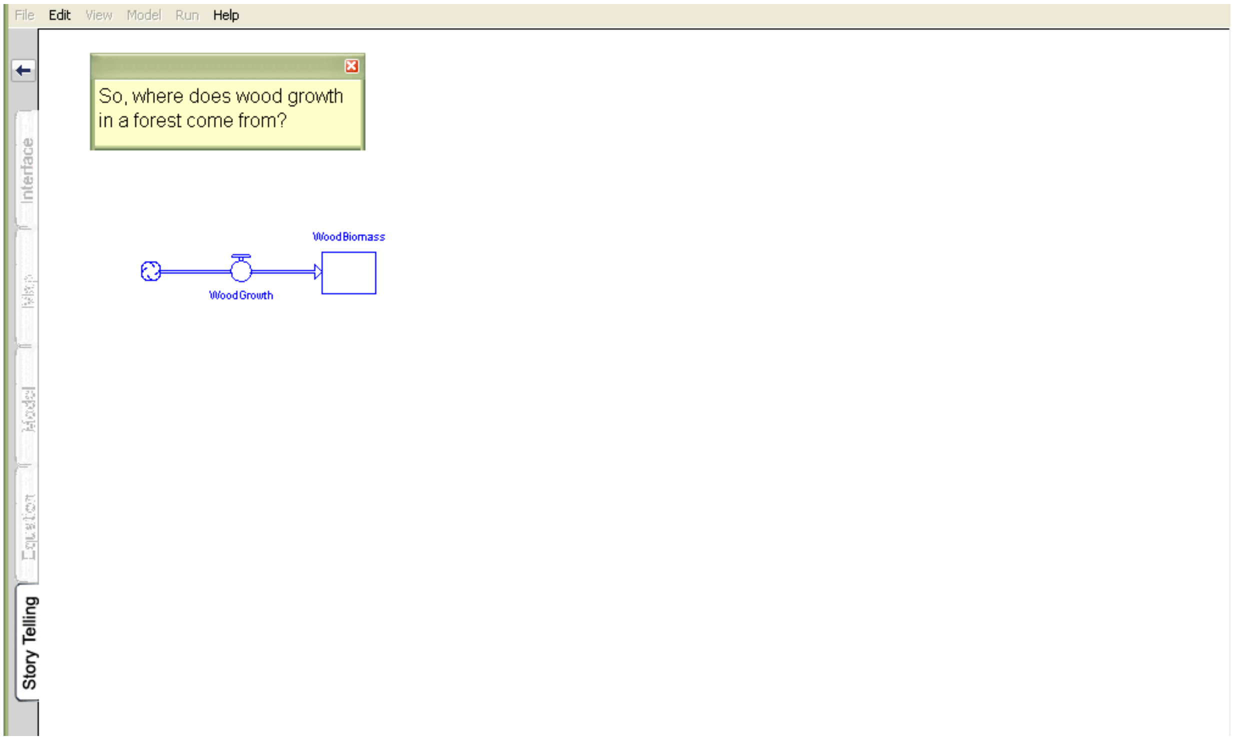
WoodBiomass
WoodGrowth
In any forest, the flow of wood into the biomass pool is from growth.
**Note that, in any model, the flow of material into or out of a given pool is called a "flux."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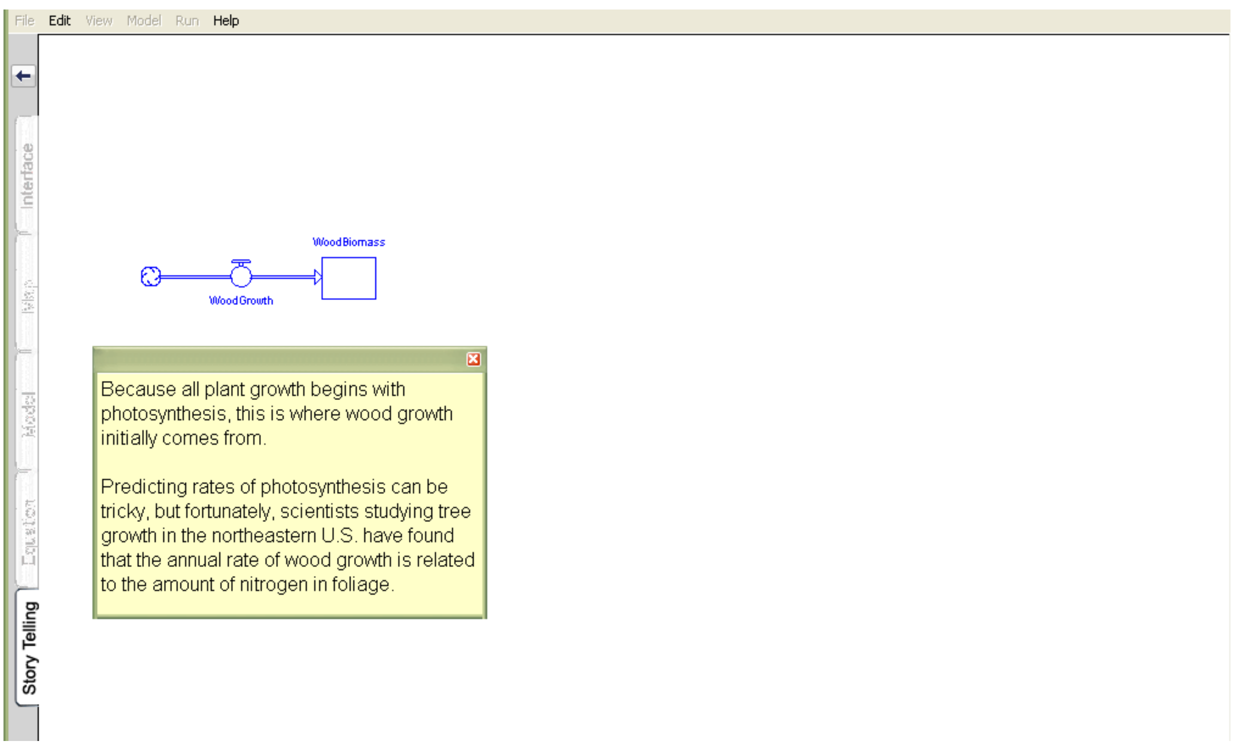
So, where does wood growth in a forest come from?
WoodBiomass
WoodGrowth
Interface
Model
Story Telling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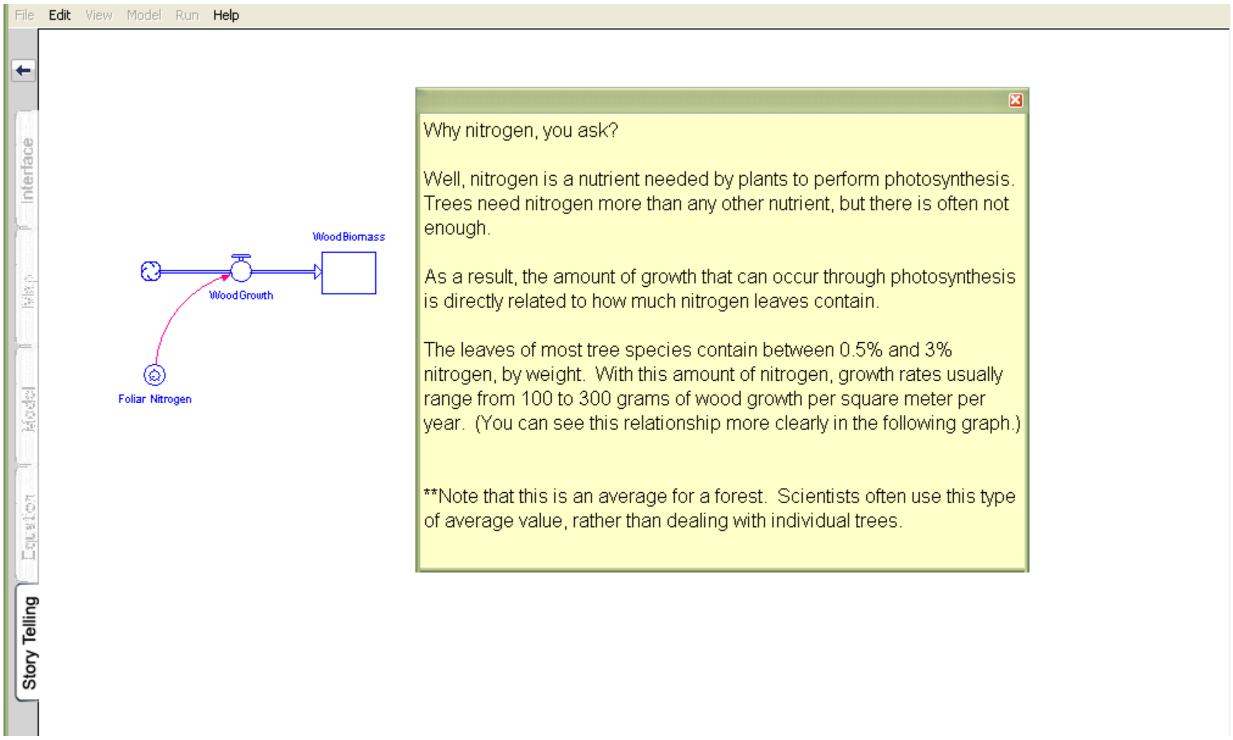
WoodBiomass
WoodGrowth
Because all plant growth begins with photosynthesis, this is where wood growth initially comes from.
Predicting rates of photosynthesis can be tricky, but fortunately, scientists studying tree growth in the northeastern U.S. have found that the annual rate of wood growth is related to the amount of nitrogen in foliage.
Interface
Model
Story Telling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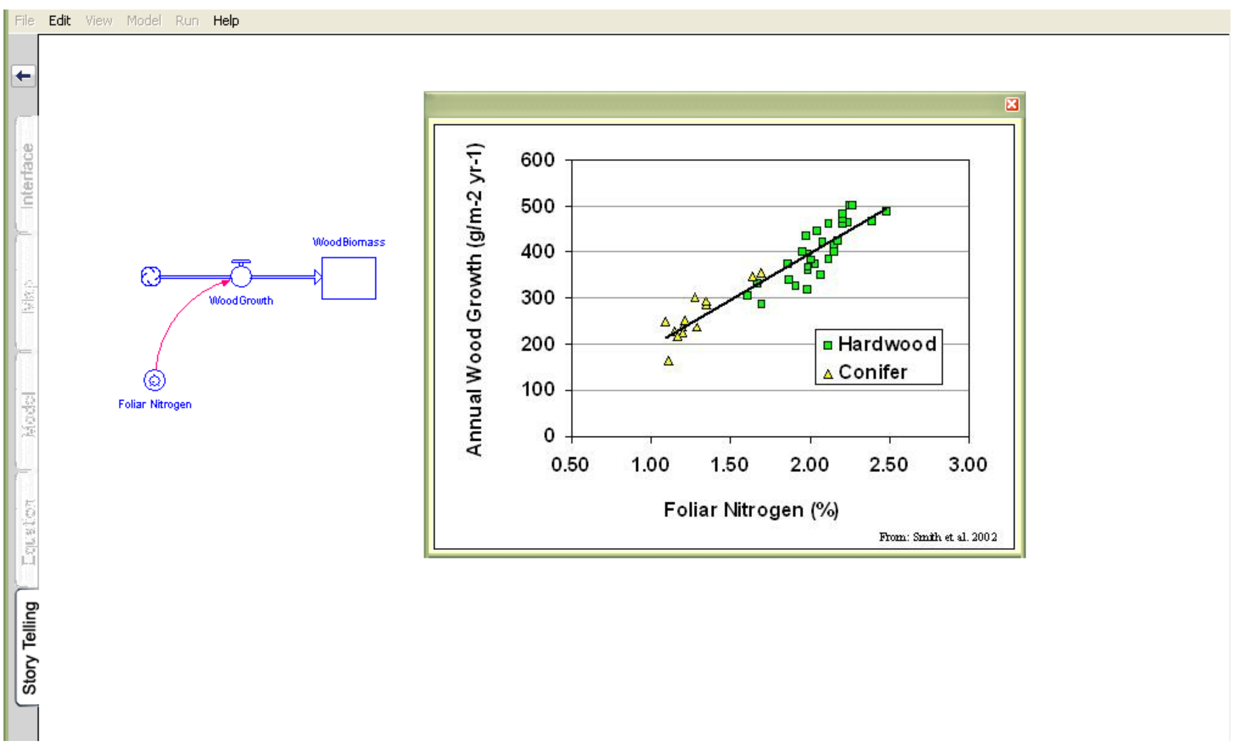
WoodBiomass
WoodGrowth
Foliar Nitrogen
Why nitrogen, you ask?
Well, nitrogen is a nutrient needed by plants to perform photosynthesis. Trees need nitrogen more than any other nutrient, but there is often not enough.
As a result, the amount of growth that can occur through photosynthesis is directly related to how much nitrogen leaves contain.
The leaves of most tree species contain between 0.5% and 3% nitrogen, by weight. With this amount of nitrogen, growth rates usually range from 100 to 300 grams of wood growth per square meter per year. (You can see this relationship more clearly in the following graph.)
**Note that this is an average for a forest. Scientists often use this type of average value, rather than dealing with individual trees.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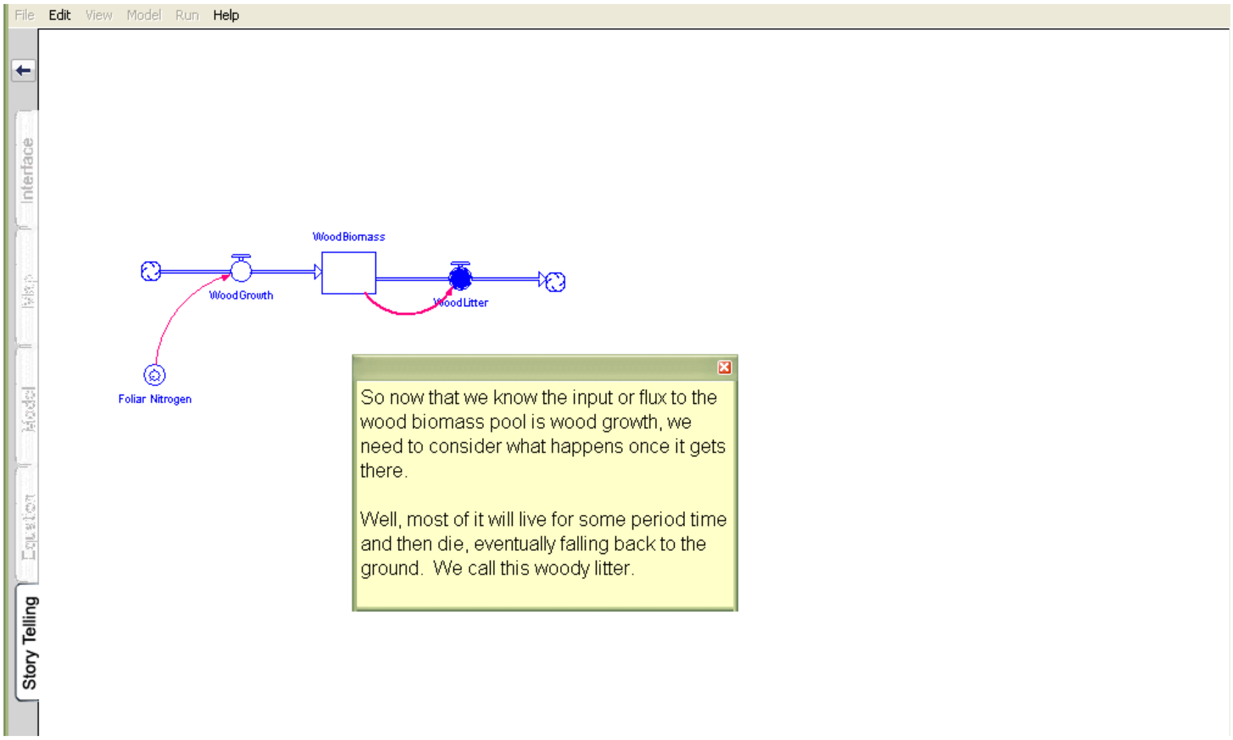
WoodBiomass
WoodGrowth
Foliar Nitrogen
Annual Wood Growth (g/m-2 yr-1)
600
500
400
300
200
100
0
0.50
1.00
1.50
2.00
2.50
3.00
Foliar Nitrogen (%)
Hardwood
Conifer
From: Smith et al. 2002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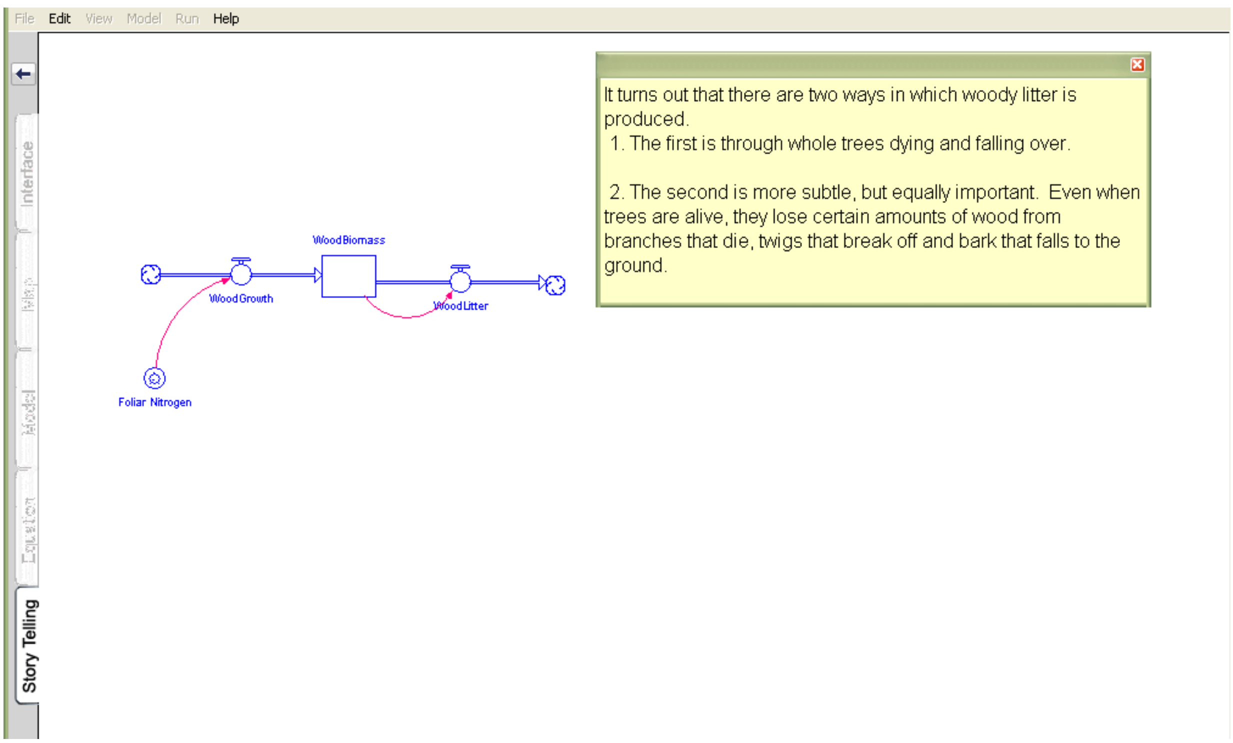
Story Telling
Wood Biomass
Wood Growth
Wood Litter
Foliar Nitrogen
So now that we know the input or flux to the wood biomass pool is wood growth, we need to consider what happens once it gets there.
Well, most of it will live for some period time and then die, eventually falling back to the ground. We call this woody litter.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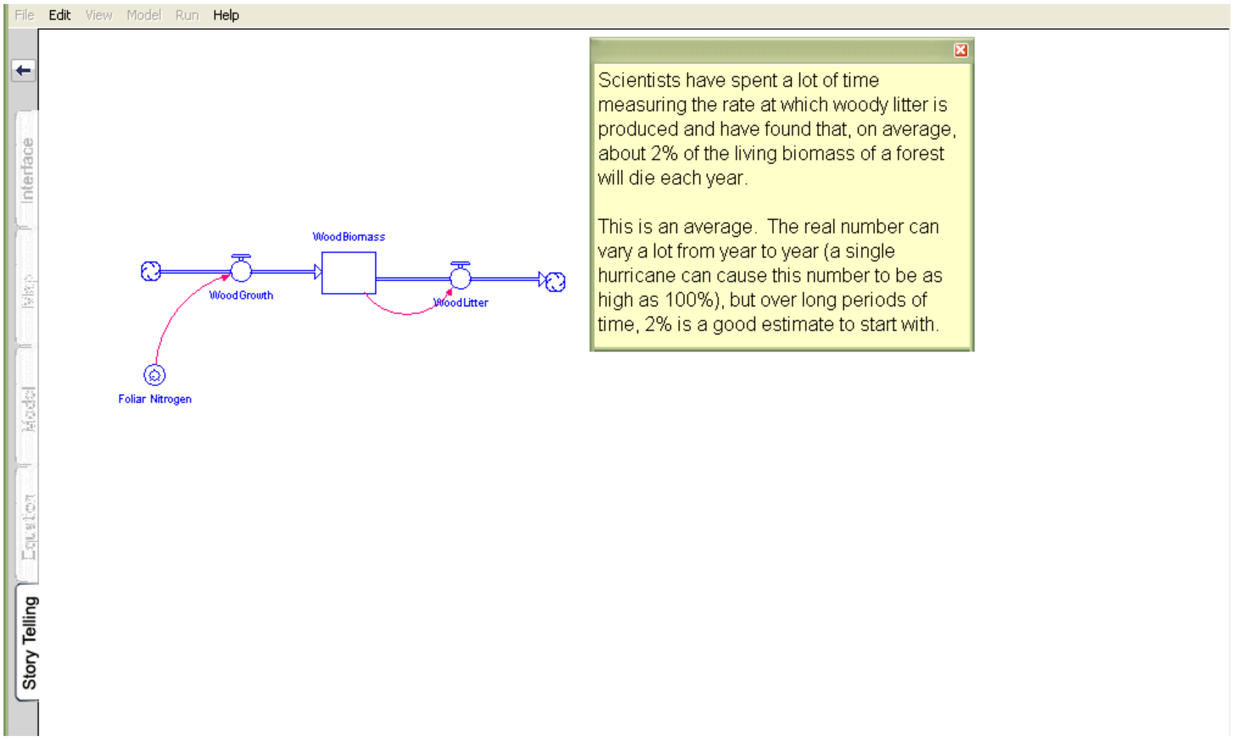
Wood Biomass
Wood Growth
Wood Litter
Foliar Nitrogen
It turns out that there are two ways in which woody litter is produced.
1. The first is through whole trees dying and falling over.
2. The second is more subtle, but equally important. Even when trees are alive, they lose certain amounts of wood from branches that die, twigs that break off and bark that falls to the ground.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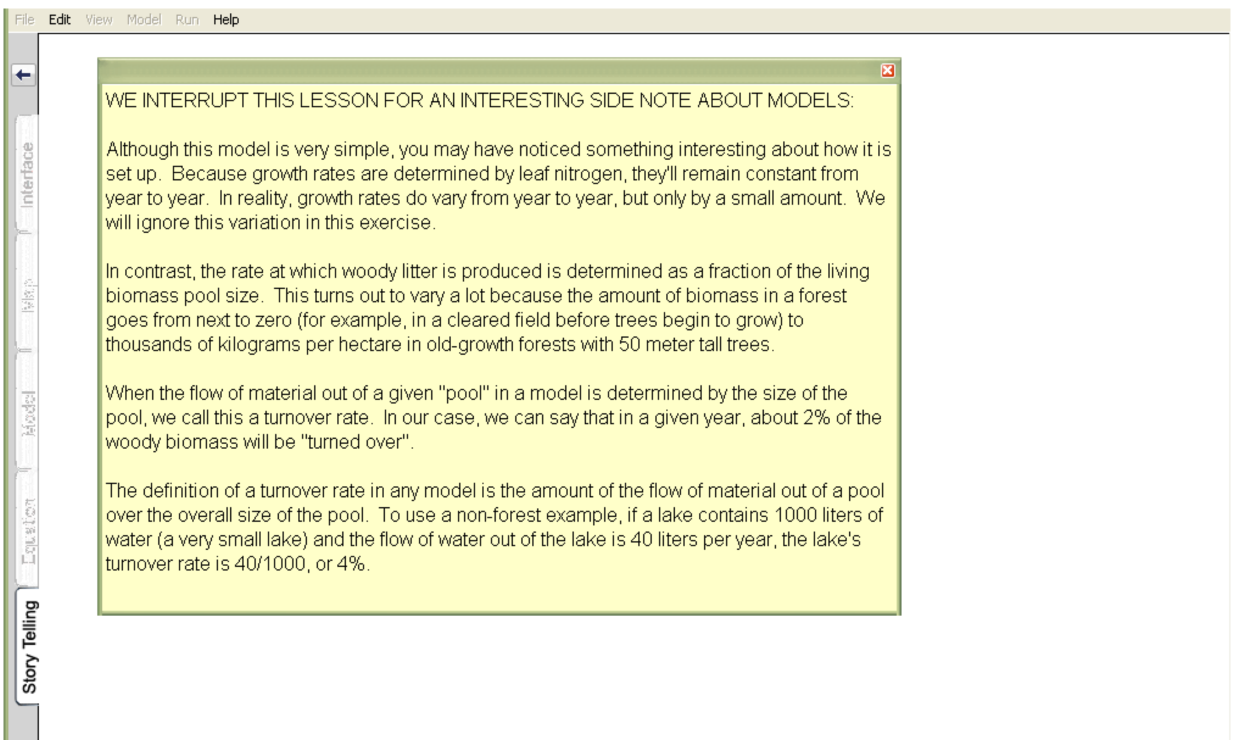
Scientists have spent a lot of time measuring the rate at which woody litter is produced and have found that, on average, about 2% of the living biomass of a forest will die each year.
This is an average. The real number can vary a lot from year to year (a single hurricane can cause this number to be as high as 100%), but over long periods of time, 2% is a good estimate to start with.
WoodBiomass
WoodGrowth
WoodLitter
Foliar Nitrogen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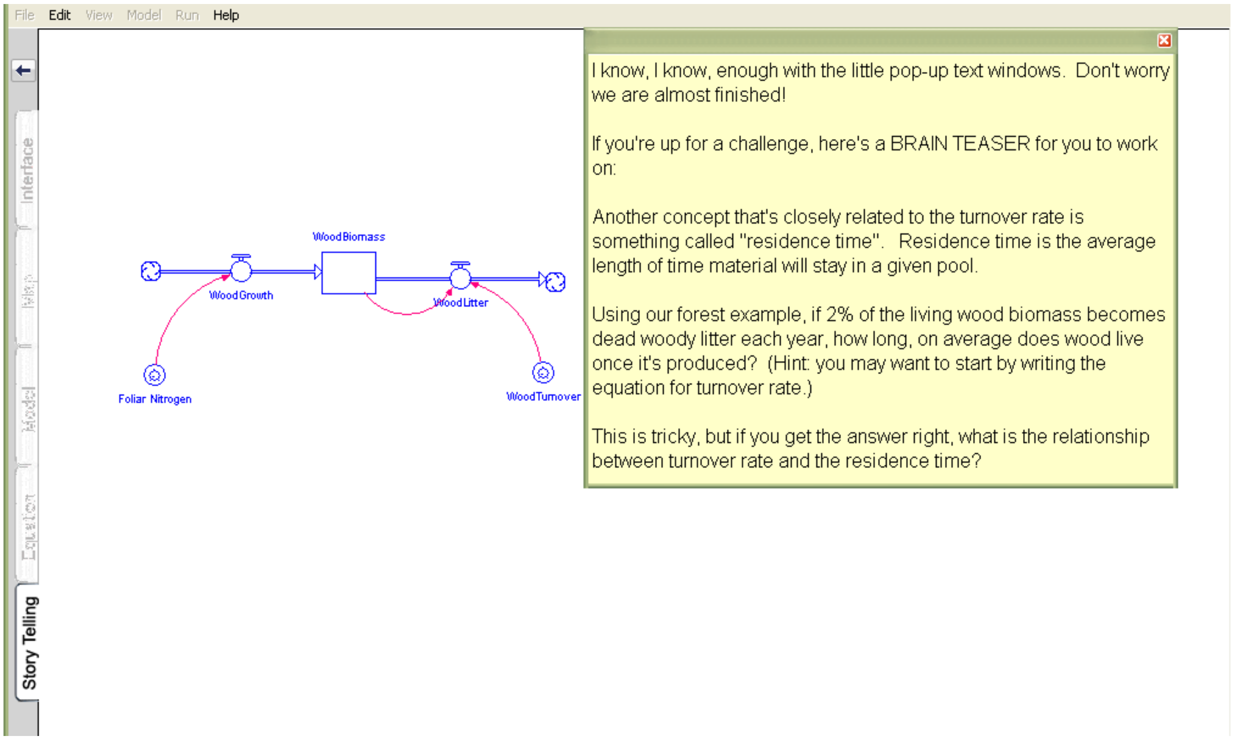
WE INTERRUPT THIS LESSON FOR AN INTERESTING SIDE NOTE ABOUT MODELS:
Although this model is very simple, you may have noticed something interesting about how it is set up. Because growth rates are determined by leaf nitrogen, they'll remain constant from year to year. In reality, growth rates do vary from year to year, but only by a small amount. We will ignore this variation in this exercise.
In contrast, the rate at which woody litter is produced is determined as a fraction of the living biomass pool size. This turns out to vary a lot because the amount of biomass in a forest goes from next to zero (for example, in a cleared field before trees begin to grow) to thousands of kilograms per hectare in old-growth forests with 50 meter tall trees.
When the flow of material out of a given "pool" in a model is determined by the size of the pool, we call this a turnover rate. In our case, we can say that in a given year, about 2% of the woody biomass will be "turned over".
The definition of a turnover rate in any model is the amount of the flow of material out of a pool over the overall size of the pool. To use a non-forest example, if a lake contains 1000 liters of water (a very small lake) and the flow of water out of the lake is 40 liters per year, the lake's turnover rate is 40/1000, or 4%.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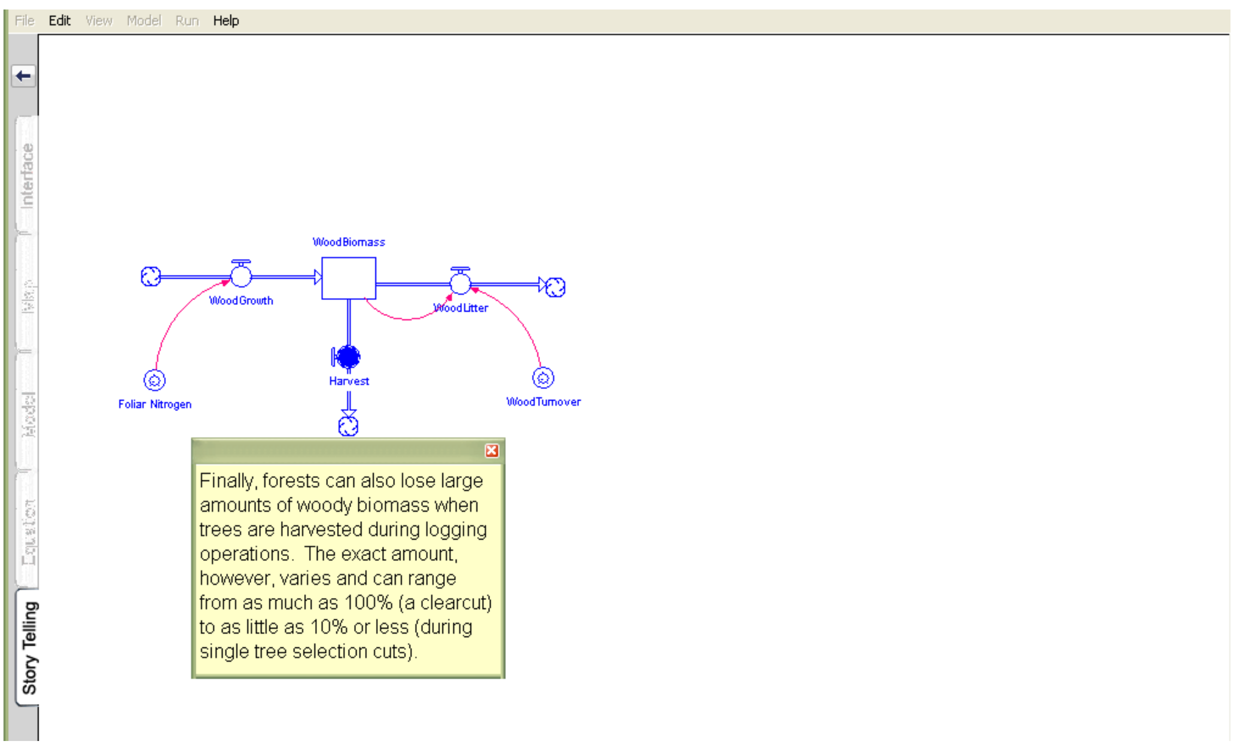
Story Telling
WoodBiomass
WoodGrowth
WoodLitter
Foliar Nitrogen
WoodTurnover
I know, I know, enough with the little pop-up text windows. Don't worry we are almost finished!
If you're up for a challenge, here's a BRAIN TEASER for you to work on:
Another concept that's closely related to the turnover rate is something called "residence time". Residence time is the average length of time material will stay in a given pool.
Using our forest example, if 2% of the living wood biomass becomes dead woody litter each year, how long, on average does wood live once it's produced? (Hint: you may want to start by writing the equation for turnover rate.)
This is tricky, but if you get the answer right, what is the relationship between turnover rate and the residence time?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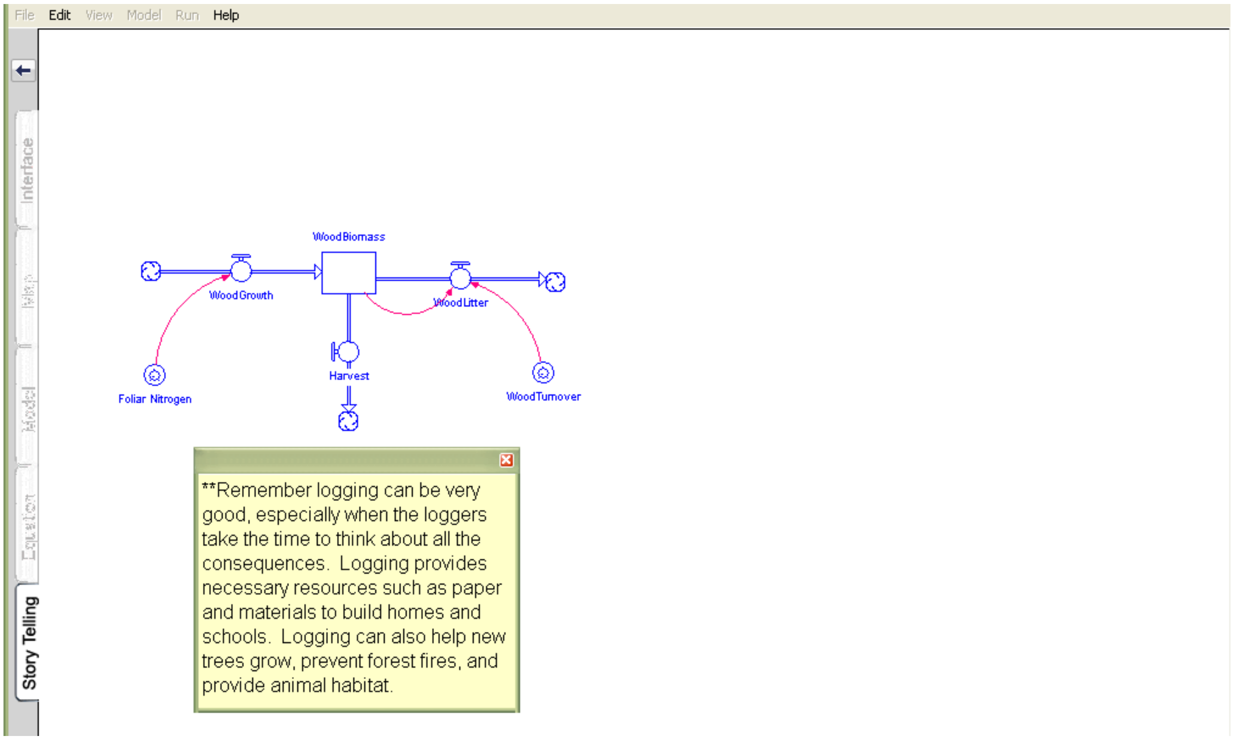
WoodLitter
Harvest
Foliar Nitrogen
WoodTurnover
Finally, forests can also lose large amounts of woody biomass when trees are harvested during logging operations. The exact amount, however, varies and can range from as much as 100% (a clearcut) to as little as 10% or less (during single tree selection cuts).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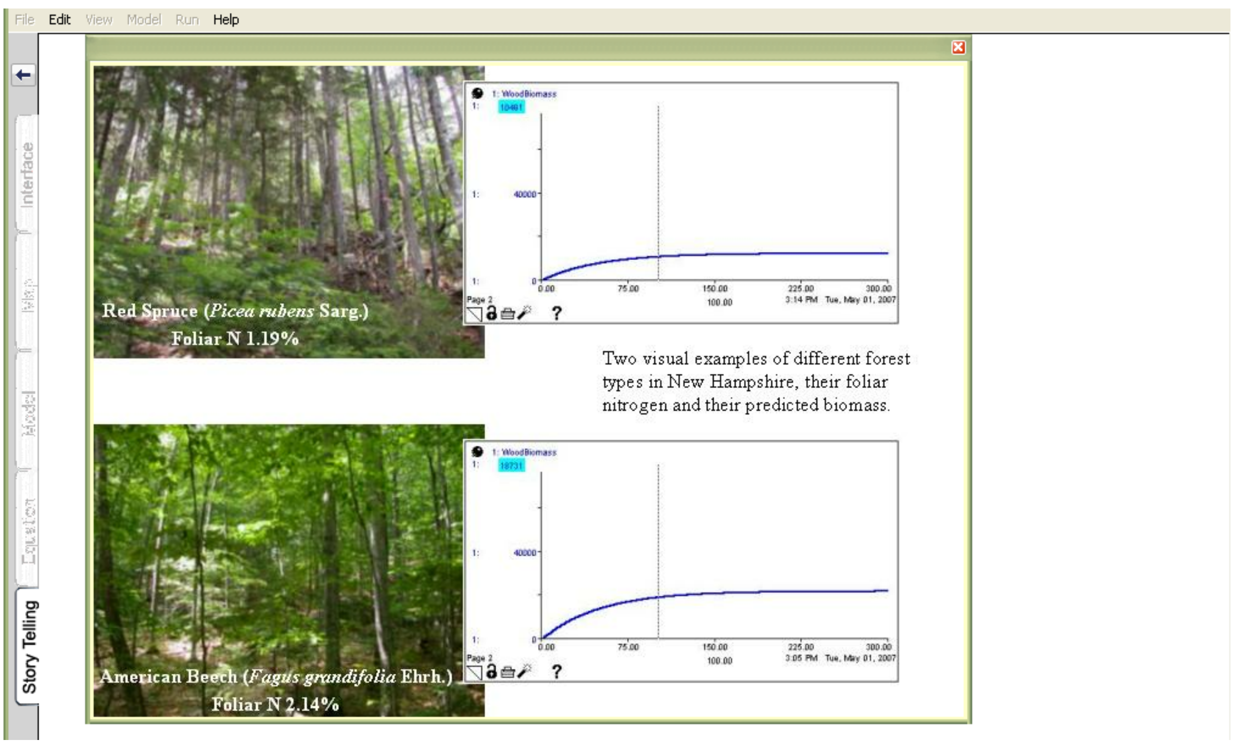
**Remember logging can be very good, especially when the loggers take the time to think about all the consequences. Logging provides necessary resources such as paper and materials to build homes and schools. Logging can also help new trees grow, prevent forest fires, and provide animal habitat.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Equation
Story Telling
Red Spruce (*Picea rubens* Sarg.)
Foliar N 1.19%
1: WoodBiomass
40000
0
0.00 75.00 150.00 225.00 300.00
100.00
3:14 PM Tue, May 01, 2007
Two visual examples of different forest types in New Hampshire, their foliar nitrogen and their predicted biomass.
American Beech (*Fagus grandifolia* Ehrh.)
Foliar N 2.14%
1: WoodBiomass
40000
0
0.00 75.00 150.00 225.00 300.00
100.00
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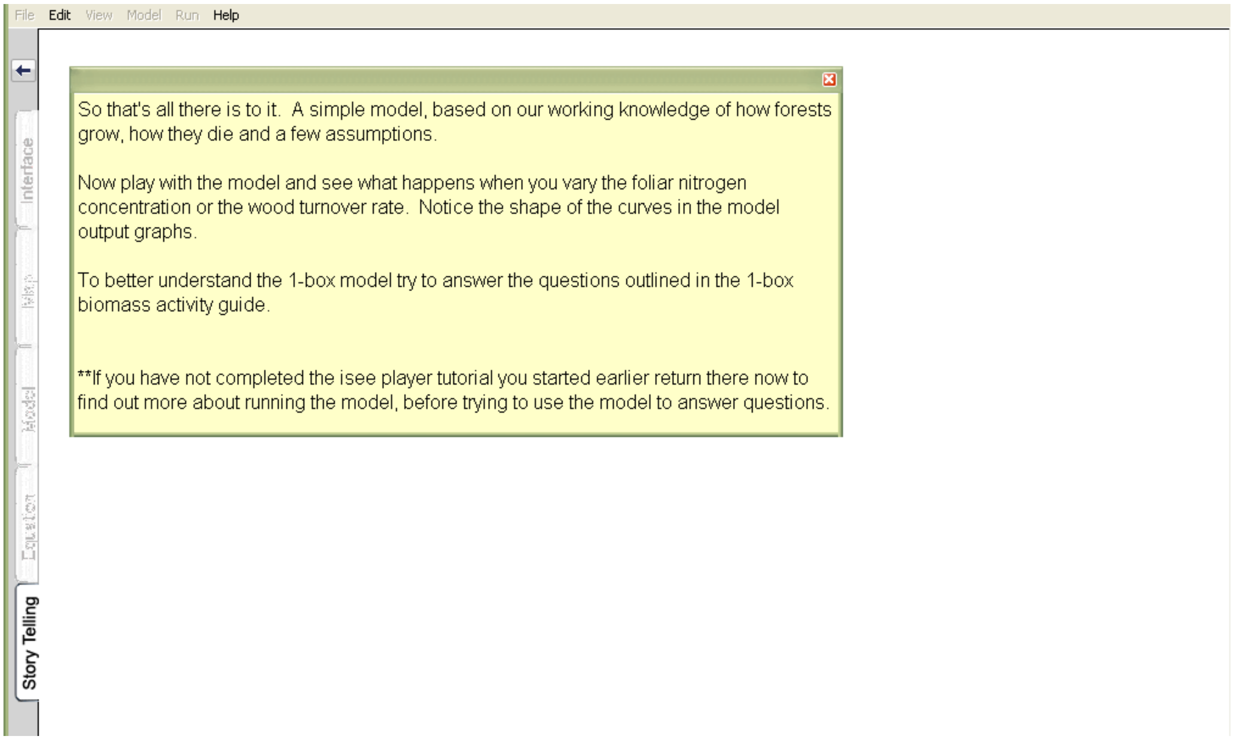
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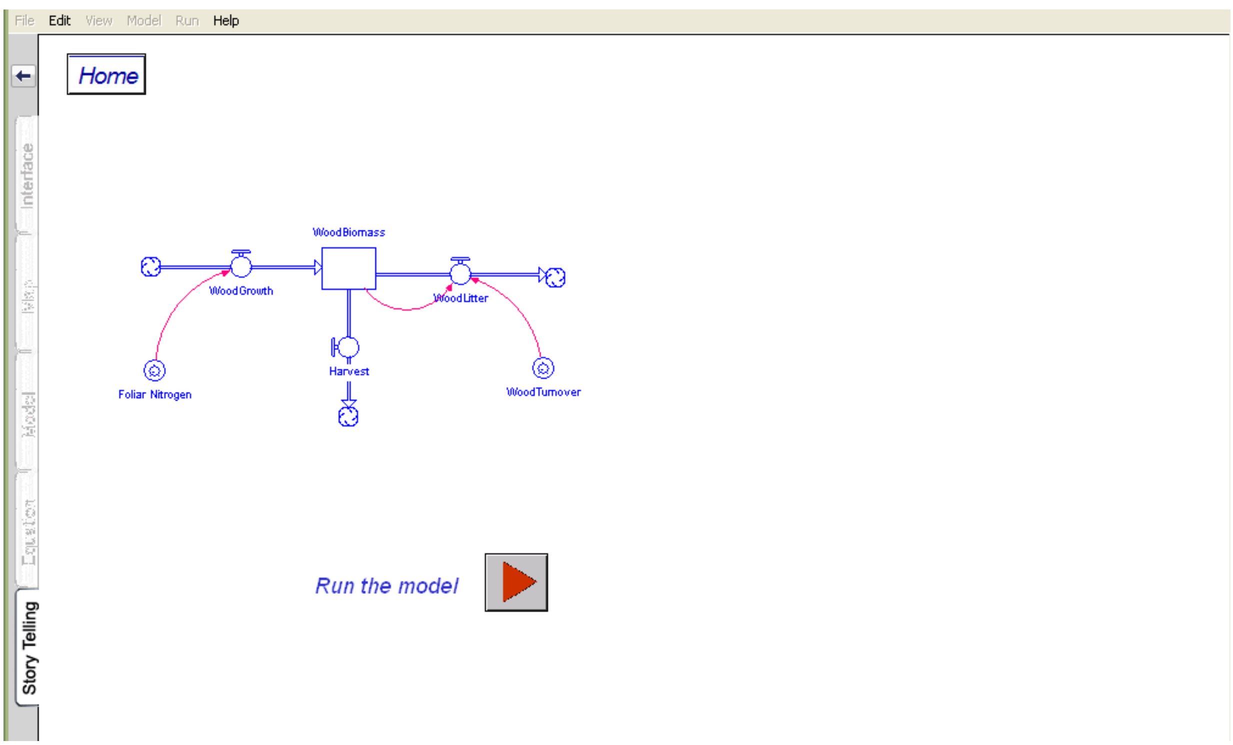
So that's all there is to it. A simple model, based on our working knowledge of how forests grow, how they die and a few assumptions.
Now play with the model and see what happens when you vary the foliar nitrogen concentration or the wood turnover rate. Notice the shape of the curves in the model output graphs.
To better understand the 1-box model try to answer the questions outlined in the 1-box biomass activity guide.
**If you have not completed the isee player tutorial you started earlier return there now to find out more about running the model, before trying to use the model to answer questions.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Home
WoodBiomass
WoodGrowth
WoodLitter
Harvest
Foliar Nitrogen
WoodTurnover
Run the model