



# Status of the National Biomass Estimator Library (NBEL)

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Timber Measurements Society

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# Introduction

## NBEL

- Past, Present, Future
- Measurement and Sampling
- Demonstrations
- Questions



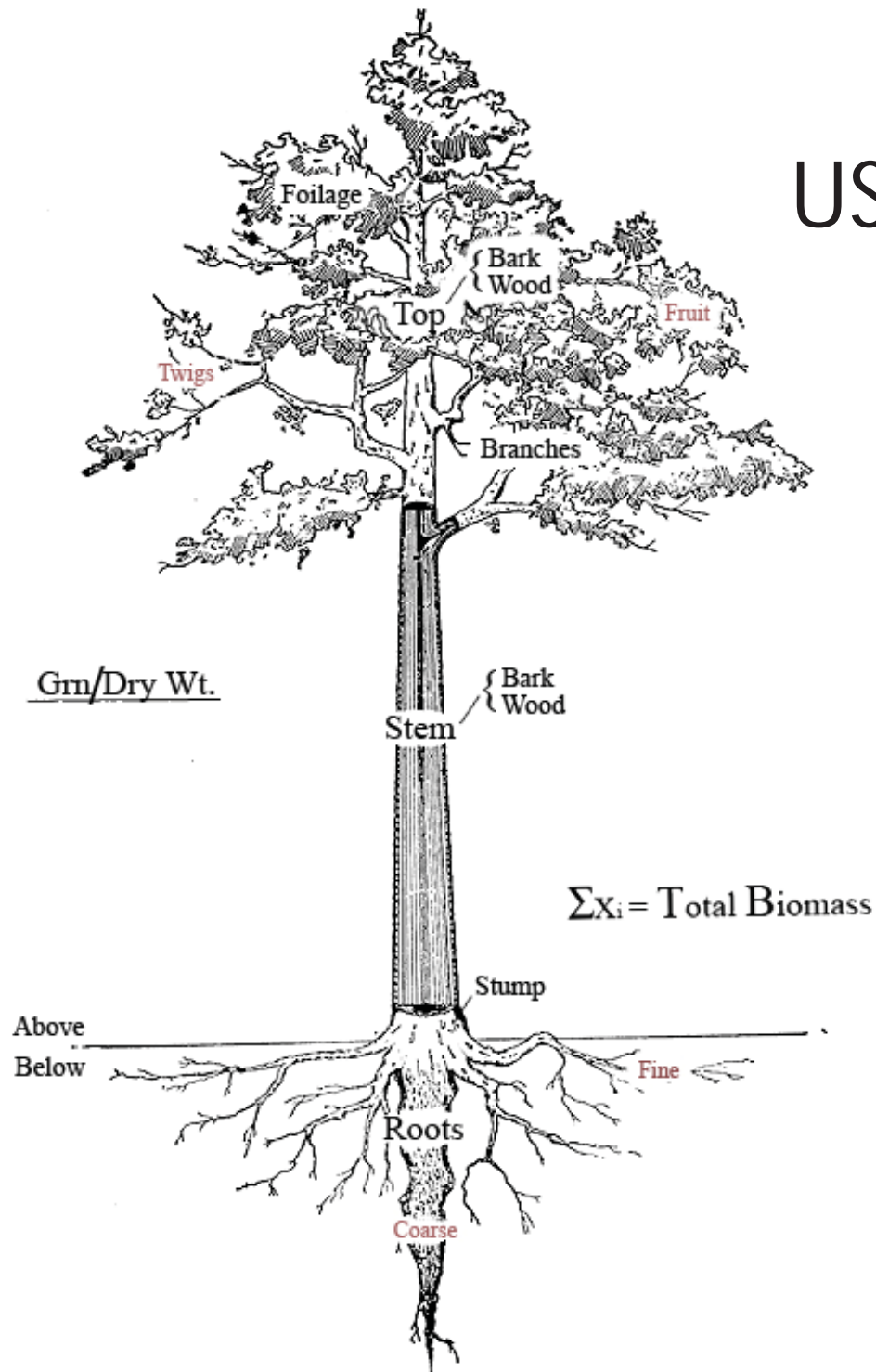


# What is biomass?

- Simple definition:
  - **biological mass** or amount (weight units) of living tissue
- **WBUG definition:**
  - “the trees and woody plants, including limbs, tops, needles, leaves, and other woody parts-grown in a forest, woodland, or rangeland environment - that are the **byproducts of forest management**”

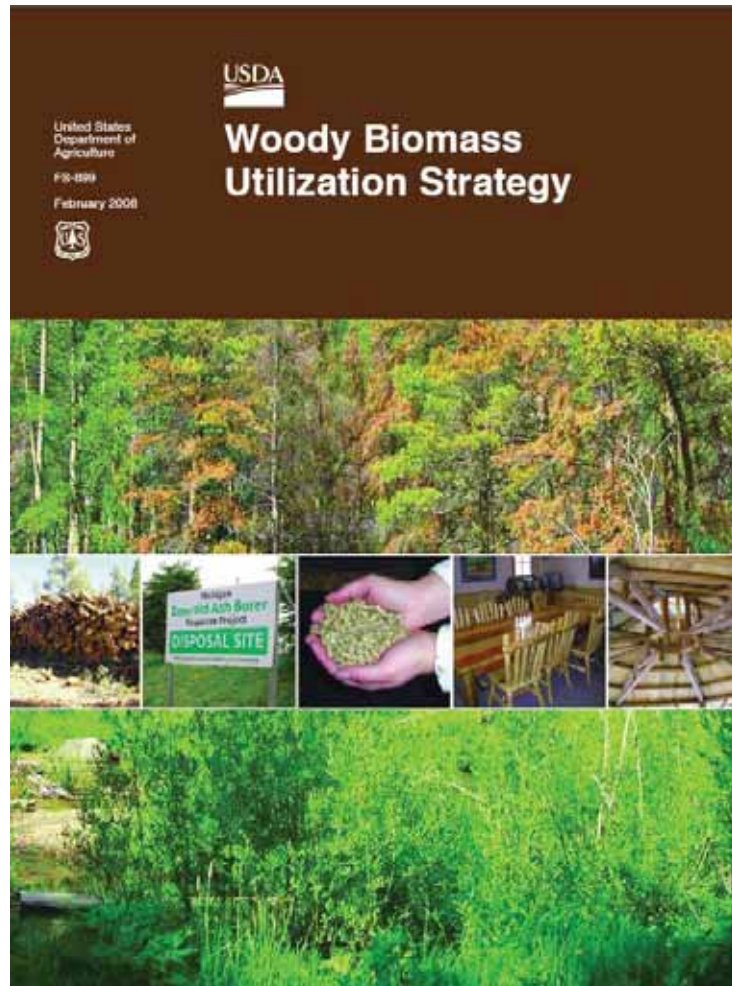


# USFS Nat. Forest System



- Components of interest
  - Aboveground
    - Wood and bark
      - Main Stem
        - » Primary Product
        - » Secondary Product
      - Branches, twigs, & top
      - Stump
    - Foliage
    - Fruit
  - Belowground
    - Stump
    - Roots (course & fine)
- Questions
  - Moisture Content?
  - What is if isn't a tree?

# National Direction



- “Our goal to increase the amount of America’s energy that comes from forests requires we coordinate to improve the **use of woody biomass** in tandem with forest management activities on public and private lands”

*Abigail R. Kimbell*

- Important for
  - commercial uses (e.g., fiber and **fuel**),
  - scientific studies of ecosystem productivity,
  - energy and nutrient flows, and
  - assessing the contribution of land-use on the **global carbon cycle**

# How NBEL started

- Changing management priorities/markets
- Renewable/sustainable energy
- NFS need for weight equation library
- 1000's of equations
- Need "simple" weight estimate
- Carbon estimates (FVS, Academia, Silviculture)
- We collected literature, synthesized and created the NBEL

# National Biomass Estimator Library

FIA and FMSC recognized a need for:

- Consistency and validation of current and future estimators
- Inter-agency cooperation
- Tech transfer and ease of use (tools)
- Complex Issue
  - Variable products, entities and equations
- BUT, where are we now?



# Where we are now

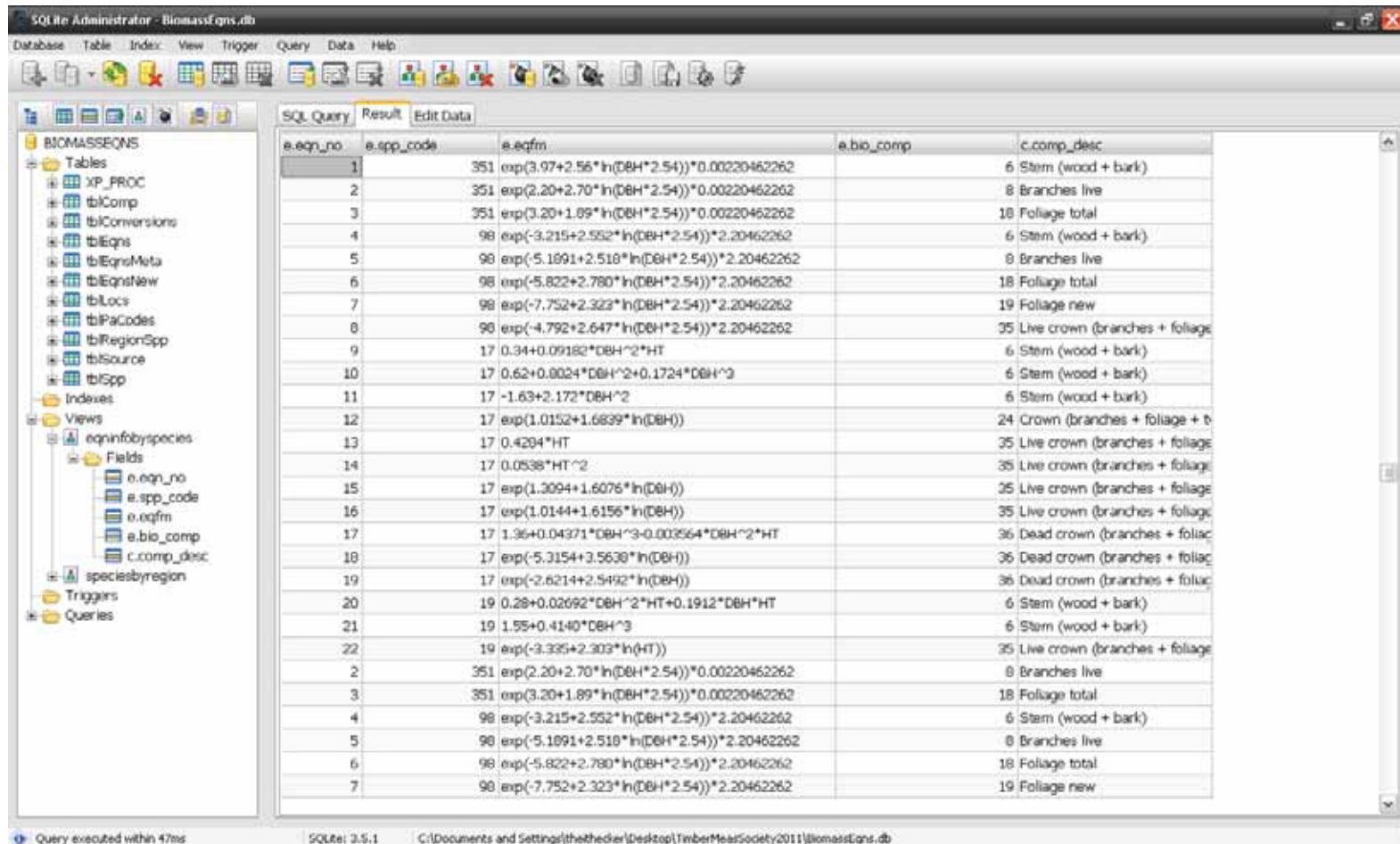
- SQLite database
- ~400 equations
- >300 species
- ~180 citations
- DBH, HT, CR
- MS Excel Add-in
- .dll
- muparser solves!





# Accessing NBEL

- Via SQLite Administrator
- This is the actual database



SQLite Administrator - BiomassEqns.db

Database Table Index View Trigger Query Data Help

SQL Query Result Edit Data

e.eqn_no	e.spp_code	e.eqfm	e.bio_comp	c.comp_desc
1	351	$\exp(3.97+2.56*\ln(\text{DBH}^2.54))*0.00220462262$	6	Stem (wood + bark)
2	351	$\exp(2.20+2.70*\ln(\text{DBH}^2.54))*0.00220462262$	8	Branches live
3	351	$\exp(3.20+1.89*\ln(\text{DBH}^2.54))*0.00220462262$	18	Foliage total
4	98	$\exp(-3.215+2.552*\ln(\text{DBH}^2.54))*2.20462262$	6	Stem (wood + bark)
5	98	$\exp(-5.1691+2.518*\ln(\text{DBH}^2.54))*2.20462262$	8	Branches live
6	98	$\exp(-5.822+2.780*\ln(\text{DBH}^2.54))*2.20462262$	18	Foliage total
7	98	$\exp(-7.752+2.323*\ln(\text{DBH}^2.54))*2.20462262$	19	Foliage new
8	98	$\exp(-4.792+2.647*\ln(\text{DBH}^2.54))*2.20462262$	35	Live crown (branches + foliage)
9	17	$0.34+0.09182*\text{DBH}^2*\text{HT}$	6	Stem (wood + bark)
10	17	$0.62+0.0024*\text{DBH}^2+0.1724*\text{DBH}^3$	6	Stem (wood + bark)
11	17	$-1.63+2.172*\text{DBH}^2$	6	Stem (wood + bark)
12	17	$\exp(1.0152+1.6839*\ln(\text{DBH}))$	24	Crown (branches + foliage + bark)
13	17	$0.4204*\text{HT}$	35	Live crown (branches + foliage)
14	17	$0.0538*\text{HT}^2$	35	Live crown (branches + foliage)
15	17	$\exp(1.3094+1.6076*\ln(\text{DBH}))$	35	Live crown (branches + foliage)
16	17	$\exp(1.0144+1.6156*\ln(\text{DBH}))$	35	Live crown (branches + foliage)
17	17	$1.36+0.04371*\text{DBH}^3-0.002564*\text{DBH}^2*\text{HT}$	36	Dead crown (branches + foliage)
18	17	$\exp(-5.3154+3.5638*\ln(\text{DBH}))$	36	Dead crown (branches + foliage)
19	17	$\exp(-2.6214+2.5492*\ln(\text{DBH}))$	36	Dead crown (branches + foliage)
20	19	$0.28+0.02692*\text{DBH}^2*\text{HT}+0.1912*\text{DBH}*\text{HT}$	6	Stem (wood + bark)
21	19	$1.55+0.4140*\text{DBH}^3$	6	Stem (wood + bark)
22	19	$\exp(-3.335+2.303*\ln(\text{HT}))$	35	Live crown (branches + foliage)
2	351	$\exp(2.20+2.70*\ln(\text{DBH}^2.54))*0.00220462262$	8	Branches live
3	351	$\exp(3.20+1.89*\ln(\text{DBH}^2.54))*0.00220462262$	18	Foliage total
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Query executed within 47ms

SQLite: 3.5.1 C:\Documents and Settings\jthehecker\Desktop\TimberMeasSociety2011\BiomassEqns.db

# Accessing NBEL

## Via Cruise Processing

The screenshot displays the 'CruiseProcessing - Version 03.18.2010' application window. The main interface includes a 'NATIONAL CRUISE PROCESSING PROGRAM' header, a 'Filename' input field, and an 'Equation numbers' button. A blue arrow points from the 'Equation numbers' button to the 'Equation Numbers' dialog box.

The 'Species List' dialog box is open, showing a list of species names: Douglas-fir, Engelmann spruce, Pacific madrone, bigleaf maple, giant chinkapin, golden chinkapin, grand fir, lodgepole pine, ponderosa pine, and red alder. A blue arrow points from the 'Equation numbers' button to the 'Species List' dialog box.

The 'Equation Numbers' dialog box is titled 'Select Weight Equation Numbers' and shows '1 of 16 WEIGHT equations.' It includes a 'Review' button and a table of equation data:

Equation number	Species code	Live/Dead Code
GENPP004	WF	

Primary Product	Weight Factor	Percent Removed (e.g., 95)
01	69.0000	100
Secondary Product	Weight Factor	Percent Removed (e.g., 95)
08	110.0000	100

Additional options include a checked checkbox for 'Component non-product BIOMASS associated with equation number' and a 'Biomass Product' field set to 8. Below these are fields for 'Foliage', 'Live Branches', 'Dead Branches', and 'Total Tree', each with a dropdown menu and associated 'Percent Moisture' and 'Percent removed' fields. A blue arrow points to the 'Foliage' dropdown menu.

Navigation buttons at the bottom include 'Add a Record', 'Previous', 'Next', 'Return', and 'Delete Record'.

# Accessing NBEL

- Via Excel Add-in

The screenshot shows the Microsoft Excel interface with the Function Arguments dialog box open for the `SolveEquation` function. The spreadsheet data is as follows:

	A	B	C	D	E	F	G
1							
2	Species by Region	Douglas-fir,Engelmann sp					
3	Species Code	202					
4	Equation #s by species/component	63,64,156					
5	Location	Oregon					
6	Citation	Helgerson et al. 1988					
7	Solve the Equation	318.9212597					
8							
9							
10							
11							
12							
13							

The Function Arguments dialog box for `SolveEquation` is displayed, showing the following fields:

- EqNum**: [Empty field]
- Var1**: [Empty field]
- Var2**: [Empty field]
- Var3**: [Empty field]

Below the fields, the text "No help available." and "EqNum" are visible. At the bottom of the dialog, there are "OK" and "Cancel" buttons.

# Accessing NBEL

Simple testing programs.

The screenshot shows a software application window titled "Form1" with a light gray background. At the top, there is a "Region" label above a text input field containing the number "9". Below this is a "Get Species" button. A table with three columns: "region", "species", and "commonName" is displayed. The table contains six rows of data, with the row for species "400" (hickory spp.) highlighted. Below the table is the text "View equations for selected species" and a "View Equations" button. Another table with three columns: "EQN\_NO", "SPP\_CODE", and "EQFM" is shown below. The first five rows of this table contain data for species "400". To the right of the application, there is a "Species Common Name" label above a text input field containing "Douglas-fir". Below this is a "Get Species Num" button, and at the bottom right, another text input field containing the number "202".

Region  
9

Get Species

region	species	commonName
9	375	paper birch
9	379	gray birch
9	391	American hornbeam,musclewood
9	400	hickory spp.
9	402	bitternut hickory
9	403	pignut hickory

View equations for selected species

View Equations

EQN_NO	SPP_CODE	EQFM
2052	400	exp{-2.0127+2.43... 2
2053	400	exp{-2.0127+2.43... 1
2054	400	exp{-2.0127+2.43... 5
2055	400	exp{-2.0127+2.43... 4
2056	400	exp{-2.0127+2.43... 8

Species Common Name  
Douglas-fir

Get Species Num

202



# Where we would like to be

- Moisture Contents
  - Woody handbook
  - May need **components** (just main stem now)
  - Supplement with more studies/data
- Weight Factors
  - Good **main stem** data
    - Currently used by regions
    - No component data - RBS
  - Not in NBEL...**yet**
- Local Data
  - Rather than national eqns



# How do we (and you) get there?

- Contact us!
- All of our products public domain





# Who are we?



- **Forest Management Service Center**
  - Biometric and mensuration specialists
  - Tech. transfer, national directions, and collaboration
  - Responsible for:
    - Forest Vegetation Simulator (FVS)
    - National Cruise System (NCS)
    - National Volume Estimator Library (NVEL)
    - National Biomass Estimator Library (NBEL)
- Well suited to tackle these issues
  - We've done it before!



# Weight Factors

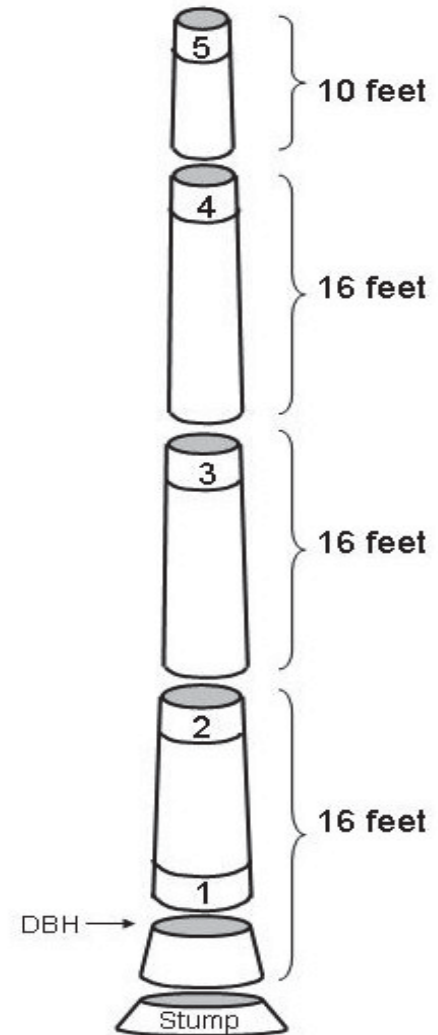
- Weight factors
  - **BEF: Biomass Expansion Factors**
- Sources of weight factors
  - Existing tables and publications, historical data
  - Traditional stick scale with load weight
  - Xylodensimeter
  - Scaling and weighing “chunks” of trees in the field





# Segmentation for Weight Factors

- Fell the tree
- Divide tree into 16 foot logs
- Select 2-foot section at top of each log and DBH
- Weigh each section
- Determine cubic volume for each section
- Weight Factor is total weight/total volume

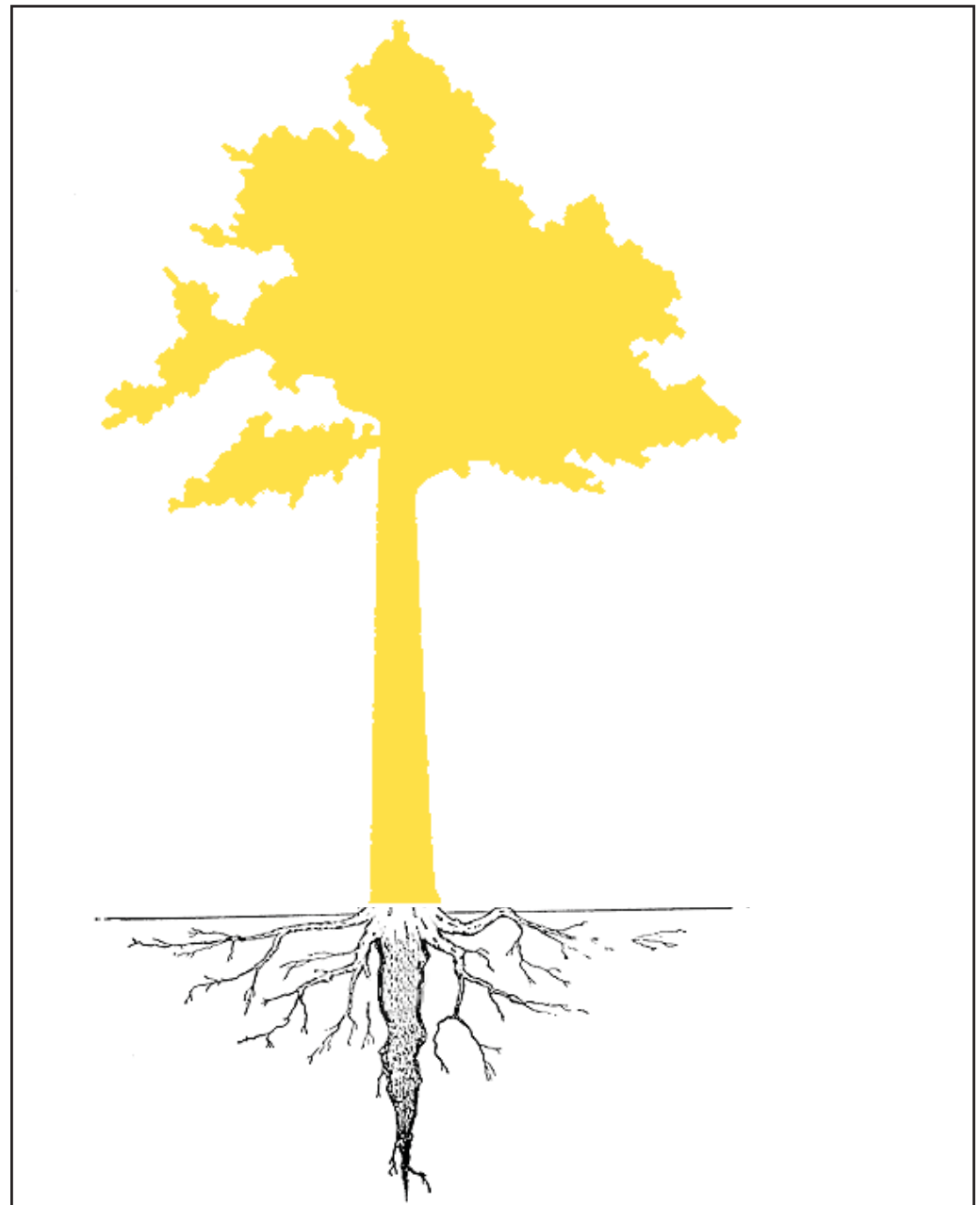


# Whole-Tree (Estimates?)

Exactly what it sounds like...

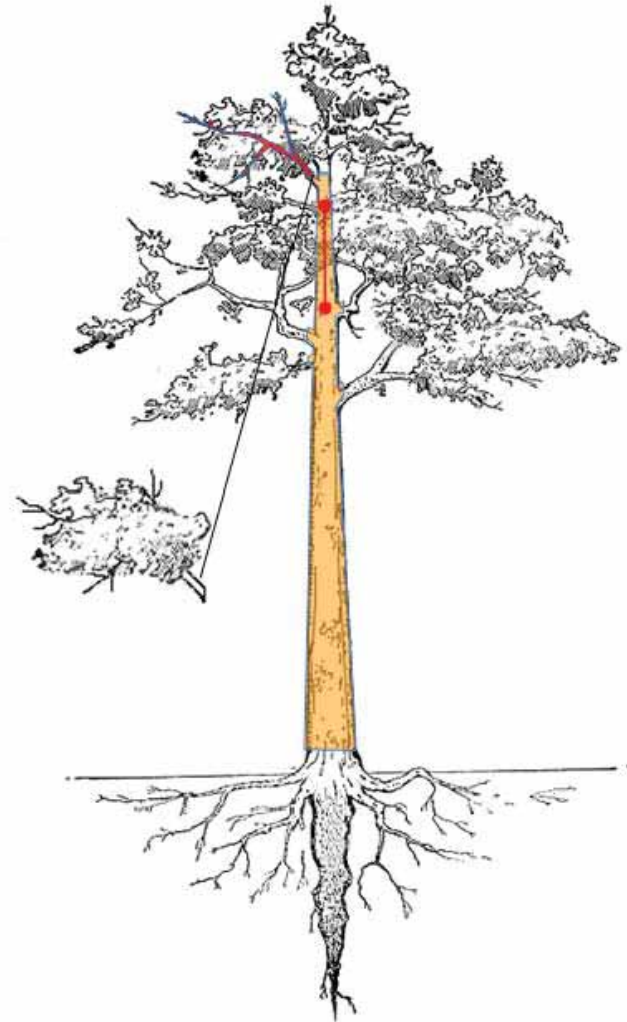
## Whole-Tree Methods

1. Fell the tree
2. Parse components
3. Weigh and repeat as needed



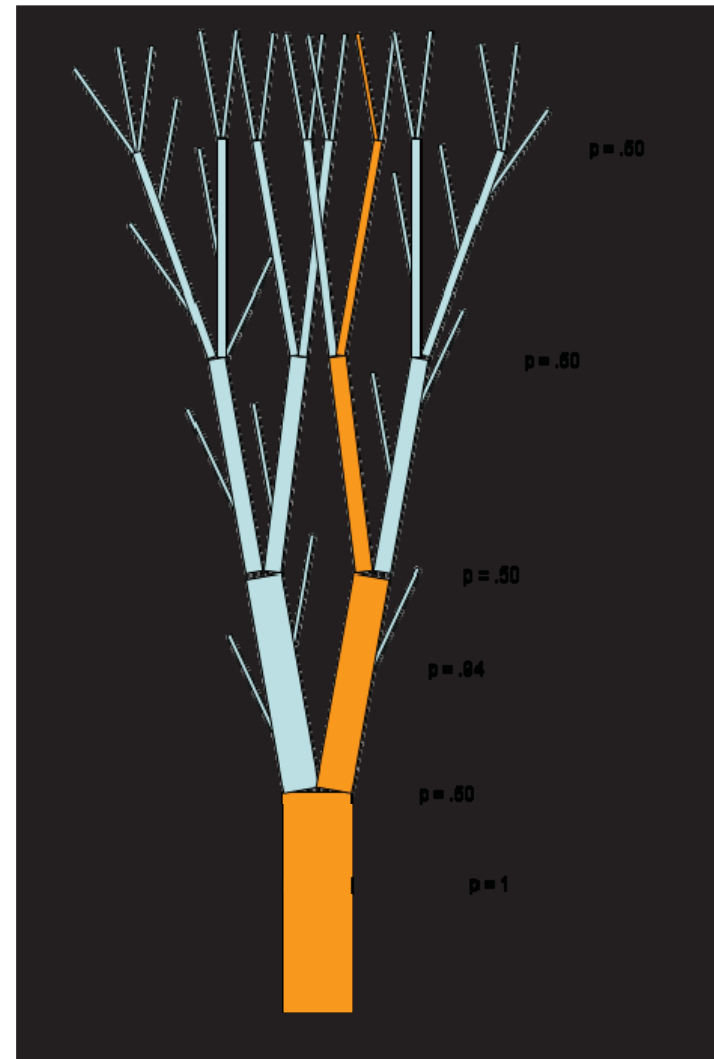
# Randomized Branch Sampling

- Jessen (1955) estimating fruit counts
- Fell tree
- Select branch as follows:
  - Measure diameter of **branches**
  - Measure the diameter of **bole**
  - Sum the squares of the diameters
  - Random number between 1 and SS diameters.
  - Select **branch or main bole**



# Randomized Branch Sampling

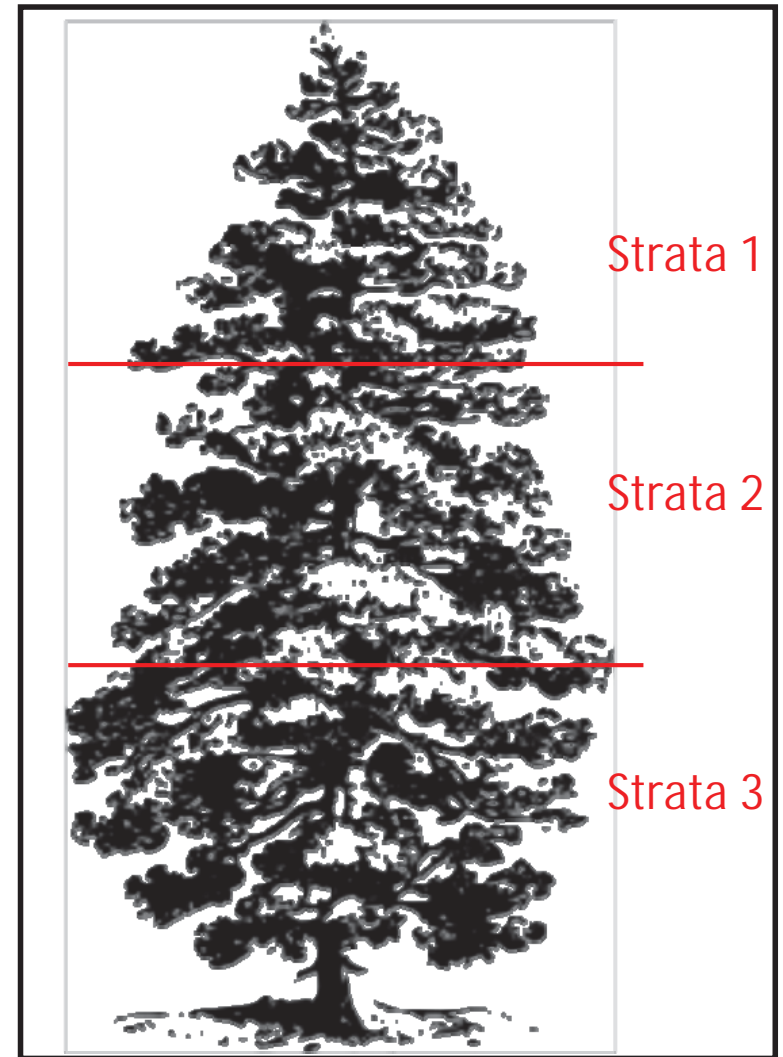
- Select branch as follows (cont.):
  - If main stem selected, move to next **branch**
  - If branch selected, remove branch, divide branch into components, weigh components
  - Branch components expanded back to tree using product of probabilities
  - Can **oven dry** components





# Stratified Randomized Branch Sampling

- Similar to previous but:
- Divide crown into strata (3+)
- Measure diameters of all branches in **strata** and sum the square
- Use List Sampling to select branch from **strata**
- Remove branch, divide branch into components, **weigh** components
- Branch components expanded back to **strata** using probability of selection
- Can oven dry the components
- Advantages?



# Conclusions

- How NBEL started
- Where **we are**.
- Where we want to **go**.
- How we can **get there**.





# Questions?

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