# ForeCost Output

## ForeCost results: Sampling economics for Mature Loblolly Pine

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### Introduction

This report details the results of a stand-level analysis run using ForeCost, SilviaTerra's inventory economics analytical tool. User-selected cruise types, cruise intensities and harvesting regimes were used to compare the costs and precisions of different sampling methods. The cost plus loss of collecting information and using imperfect information to make management decisions were compared to demonstrate the value added by selecting an appropriate inventory method to inform management decisions.

### Summary of target forest conditions

This simulation was run to compare inventory and management strategies for Mature Loblolly Pine.

The target stand conditions were:

- **State** Virginia
- **Origin** Artificial
- **Age** 30
- **TPA** 140
- **Basal Area** 80 $ft^2$ per acre

Based on these target levels and the selected plot, a simulated forest with 139 trees per acre and 76.8 $ft^2$ per acre of basal area was created.

**Among the tested sampling methods, the recommended approach for this forest type is FRP 1/10th ac plots with CruiseBoost, at an intensity of 1 plot every 10 acres.** This was selected as the most cost effective approach, while still providing enough information to make efficient management decisions.

### Sampling Methods

Simulated samples using Fixed Radius (1/10 acre), BAF 10 and BAF 20 plot types were installed at an intensity of 1 plot / 5 acres and 1 plot / 10 acres. Each sample was replicated 100 times, resulting in a total of 600 simulated inventories.

**Inventory Valuation**

The basic premise of the economic assessment used here is the comparison of cost- the cost of gathering inventory information- against the loss associated with making a suboptimal management decision based on that information.

For this simulation, we compared a series of silvicultural scenarios. These included:

- thin from above to 30 $ft^2$/acre
- thin from above to 40 $ft^2$/acre
- thin from above to 50 $ft^2$/acre
- thin from above to 60 $ft^2$/acre
- thin from above to 70 $ft^2$/acre
- thin from below to 30 $ft^2$/acre
- thin from below to 40 $ft^2$/acre
- thin from below to 50 $ft^2$/acre
- thin from below to 60 $ft^2$/acre
- thin from below to 70 $ft^2$/acre

Each management scenario was implemented at either year 1, 3, 5, 7, or 9 along the 15 year time frame, resulting in 5 possible realizations of each management scenario for each inventory. The resulting estimates of standing and removed forest volume for each sampling method, management scenario, and management year were then used to determine what the financial optimal management decision would have been under each replication of each sampling technique. The net present value at year 15, including harvesting revenues, standing timber, premerchantable timber values, and cruising costs, was calculated using an interest rate of 4%.

The optimal selection, that with the highest estimated NPV, was compared to the true financially optimal management scenario made using perfect information, drawn from the census data. The expected loss for each replication was the difference in NPV of the selected forest census management scenario and the NPV from the forest census using the inventory selected management scenario. This means the comparison was between the total possible realized value for the entire forest, and the realized value for the entire forest from an alternate management scenario- not the value expected using information from an imperfect sample.

Table 2: Census Selected Management

| Census Management | Census Value |
|---|---|
| ThinA40 at year 1 | 1147.5 |

Table 1 shows the optimal management option from the census of the entire simulated stand, resulting in a net present value of $1147.5 per acre.

The key result from all replications is the average cost per acre and the average expected loss per acre from each sampling methodology. If data from a given plot type and intensity lead to the selection of the true financially optimal management decision for each replication, then the average expected loss per acre for that sampling approach is equal to zero. The magnitude of the expected loss reflects the frequency of selecting sub-optimal management decisions, as well how far from optimal those selected decisions were.

The complete comparison of the sampling methods simulated is presented below (Table 2). The benefits of the Cruise Boost system vary by sampling intensity in plot type. In general, Cruise Boost results in a smaller cost plus loss than many of the traditional sampling procedures. The optimal inventory approach for this simulated forest is highlighted in green- this is the sampling procedure that minimizes the expected loss, while also accounting for the cost of sampling.

Table 3: Inventory Selected Management

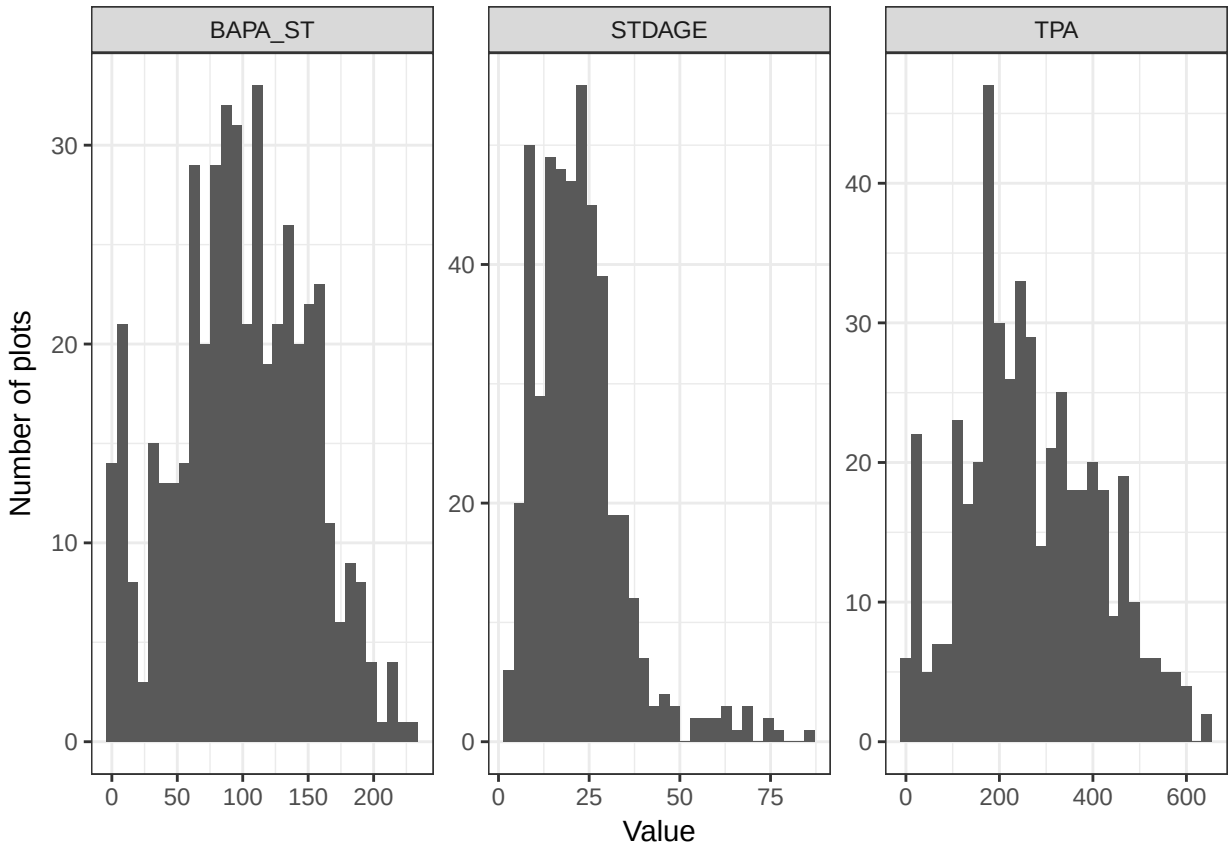
| Cruise Method | Cruise Boost? | Acres Per Plot | Number of reps | Mean Loss ($/acre) | Mean Cost ($/acre) | Mean Cost Plus Loss ($/acre) |
|---|---|---|---|---|---|---|
| FRP 1/10th ac | Yes | 10 | 100.00 | 5.96 | 3.93 | 9.89 |
| FRP 1/10th ac | Yes | 5 | 100.00 | 5.73 | 4.54 | 10.27 |
| FRP 1/10th ac | No | 10 | 100.00 | 8.63 | 2.43 | 11.06 |
| FRP 1/10th ac | No | 5 | 100.00 | 9.10 | 3.04 | 12.14 |
| BAF 10 | No | 10 | 100.00 | 13.22 | 2.19 | 15.41 |
| BAF 10 | Yes | 10 | 100.00 | 14.11 | 3.69 | 17.80 |
| BAF 20 | No | 10 | 100.00 | 16.45 | 2.03 | 18.48 |
| BAF 10 | Yes | 5 | 100.00 | 14.42 | 4.11 | 18.53 |
| BAF 20 | Yes | 10 | 100.00 | 15.18 | 3.53 | 18.71 |
| BAF 20 | No | 5 | 100.00 | 16.60 | 2.29 | 18.89 |
| BAF 20 | Yes | 5 | 100.00 | 15.74 | 3.79 | 19.53 |
| BAF 10 | No | 5 | 100.00 | 17.63 | 2.61 | 20.24 |

## Appendix

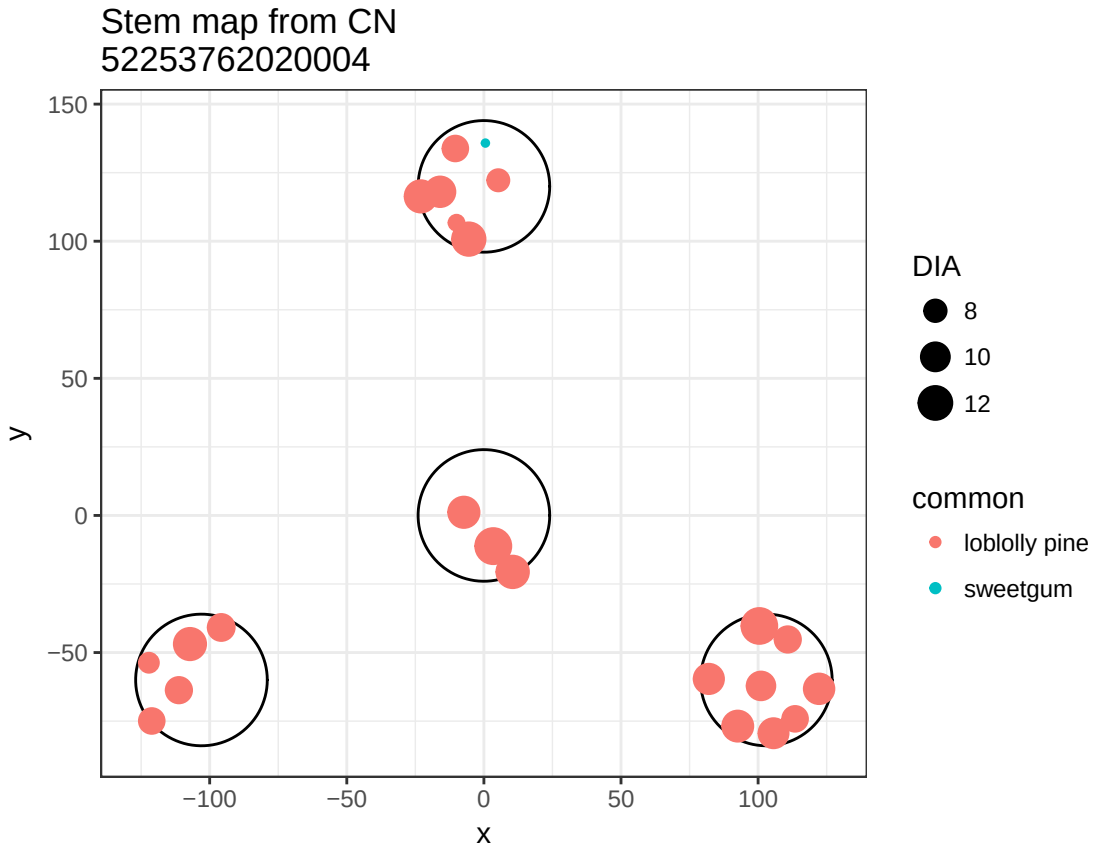
Further details about the analytic process are explained in the following sections.

### Simulated Forest Creation

472 total possible FIA plots were available for Virginia in the Loblolly pine forest type. These plots were filtered from all USFS FIA plots to include only those in forested conditions inventoried in the year 2000 or later, and to include only live trees 5 inches DBH and above. Stand ages in the available plots range from 2 to 85 years. Stand basal area ranges from 0 $ft^2$ per acre to 230 $ft^2$ per acre. Stand trees/acre ranges from 0 to 644.




The FIA plot CN 52253762020004 was the randomly chosen plot used for these analyses. The stem map for the selected plot is shown below.


Stem map from CN
52253762020004
150
100
50
0
−50
y
−100
−50
0
50
100
x
DIA
8
10
12
common
loblolly pine
sweetgum

### Forest Sampling

To estimate the cost of the sampling method, individual components of plot measurements are broken down and time estimated for each component. The time for each component was estimated based on internal SilviaTerra data, with the simulated sampling protocols specified by the user. To estimate the total cost, an hourly rate ($/hour) is multiplied by the total time. The cost components and selected values specified by the user were:

- **Walking Speed** - 4 mph
- **Number of Recorded Heights per Plot** - 2
- **Percent of Grades Recorded** - 1
- **Number of Increment Cores Taken per Plot** - 0
- **Time for high-precision GPS reading** - TRUE
- **Hourly Rate** - $30/hour
- **Fixed Travel Costs** - $250

### Stumpage Prices

Stumpage prices and product rules are specifiable by the user, but must follow the broad product breaks which are built into the FVS variant for the region. The prices and rules used for this process are shown in the table below. Note that if no values are provided then defaults of $30.99 for hardwood sawtimber, $25.60 for softwood sawtimber, and $10 for all pulpwood will be used.

Table 4: Stumpage Prices

| Name | Type | Species | Min. dbh | Max. dbh | Stumpage Price | Expected % cull |
|---|---|---|---|---|---|---|
| Default HWSaw | Hardwood Sawtimber | sweetgum | 12 | 60 | 30.99 | 0 |
| Default SWSaw | Softwood Sawtimber | loblolly pine | 10 | 60 | 25.60 | 0 |
| Default Pulp | Pulpwood | loblolly pine | 0 | 60 | 10.00 | 0 |
| Default Pulp | Pulpwood | sweetgum | 0 | 60 | 10.00 | 0 |

**Scenarios and expected loss**

The management scenarios that were tested are shown in the following table. For each scenario, the expected loss is shown. The scenario with an expected loss of $0 was the scenario with the highest NPV. The expected loss associated with choosing the other scenarios was calculated as the difference, in dollars per acre, between the highest NPV and the NPV for each other scenario.

Table 5: Expected Loss from Census Management Scenarios

| Management Scenario | Expected Loss |
|---|---|
| ThinB40 at year 1 | -264.78 |
| ThinA40 at year 1 | 0.00 |
| ThinB50 at year 1 | -257.80 |
| ThinA70 at year 1 | -60.18 |
| ThinA50 at year 1 | -11.12 |
| ThinB30 at year 1 | -277.95 |
| ThinA30 at year 1 | -12.87 |
| ThinA60 at year 1 | -29.16 |
| ThinB60 at year 1 | -209.20 |
| ThinB70 at year 1 | -103.16 |
| ThinB40 at year 3 | -247.85 |
| ThinA40 at year 3 | -27.81 |
| ThinB50 at year 3 | -234.49 |
| ThinA70 at year 3 | -56.57 |
| ThinA50 at year 3 | -30.08 |
| ThinB30 at year 3 | -257.99 |
| ThinA30 at year 3 | -34.73 |
| ThinA60 at year 3 | -38.90 |
| ThinB60 at year 3 | -220.04 |
| ThinB70 at year 3 | -135.60 |
| ThinB40 at year 5 | -184.90 |
| ThinA40 at year 5 | -9.87 |
| ThinB50 at year 5 | -177.51 |
| ThinA70 at year 5 | -30.54 |
| ThinA50 at year 5 | -4.49 |
| ThinB30 at year 5 | -193.16 |
| ThinA30 at year 5 | -16.60 |
| ThinA60 at year 5 | -7.41 |
| ThinB60 at year 5 | -171.54 |
| ThinB70 at year 5 | -161.49 |
| ThinB40 at year 7 | -153.92 |
| ThinA40 at year 7 | -17.60 |
| ThinB50 at year 7 | -148.20 |
| ThinA70 at year 7 | -38.49 |
| ThinA50 at year 7 | -23.29 |
| ThinB30 at year 7 | -157.67 |
| ThinA30 at year 7 | -23.89 |
| ThinA60 at year 7 | -26.95 |
| ThinB60 at year 7 | -149.42 |
| ThinB70 at year 7 | -149.26 |
| ThinB40 at year 9 | -119.91 |
| ThinA40 at year 9 | -29.09 |
| ThinB50 at year 9 | -120.50 |
| ThinA70 at year 9 | -46.12 |

| Management Scenario | Expected Loss |
|---|---|
| ThinA50 at year 9 | -25.82 |
| ThinB30 at year 9 | -120.43 |
| ThinA30 at year 9 | -31.05 |
| ThinA60 at year 9 | -32.09 |
| ThinB60 at year 9 | -120.00 |
| ThinB70 at year 9 | -121.86 |