

FBGA 2023 Annual Meeting, 11/21/2023

Quantifying and Forecasting Asper Bamboo Production in Florida

Applying Forest Inventory Methodology to Bamboo



Inventory Methods for Four Farms:

Plot Shape, Size, Configuration, Numbers of Plots and Clumps and Number of Culms Measured from June to November 2023

| | Fatout | Merrick | MFA | Hi Hat |
|--------------------|-------------------|------------------|------------------|-------------------|
| Plot Shape | Square | Rectangular | Rectangular | Rectangular |
| Plot Size | 30' x 30' | 80' x 8' | 80' x 8' | 50' x 18' |
| Plot Configuration | 3 rows x 3 clumps | 6 rows x 1 clump | 6 rows x 1 clump | 3 rows x 2 clumps |
| No. of Plots | 3 | 12 | 8 | 8 |
| Total Clumps | 27 | 72 | 48 | 48 |

Plot Procedures: Permanent Tag, Duct Tape and Number Every Culm, Measure BD of all and DBH of Some Culms

| | | | | |
|--------------|------------|--------------|------------|------------|
| June | 300 (47) | 936 (58) | 730 (13) | 680 (12) |
| July | 85 | 188 | 86 | 37 |
| August | 76 | 76 | 44 | 15 |
| September | 18 | 97 | 62 | 44 |
| October | 8 | 36 | 38 | 31 |
| November | 5 | 25 | 10 | 16 |
| Total | 492 | 1,358 | 970 | 823 |

Stand and Stock Tables: Per Acre and Total

Per Acre Stand Table: Lists Number of Culms by Diameter
Per Acre Stock Table: Lists Basal Area and Content by Diameter

Total Stand Table: Lists Total Number of Culms by Diameter
Total Stock Table: Lists Total Content by Diameter

| Culm BD | -----Per Acre----- | | | -----Total----- | |
|---------------|--------------------|----|------|-----------------|------|
| | Culms | BA | Tons | Culms | Tons |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| Total | | | | | |
| Ave BD | | | | | |
| | Culms/Clump | | | | |

Fatout - 3 Acres; 4-years-old

2022 in June

| Culm BD | -----Per Acre----- | | | -----Total----- | |
|---------------|--------------------|--------------|-------------|-----------------|------------|
| | Culms | BA | Fiber Tons | Culms | Fiber Tons |
| 1 | 1,129 | 6.2 | 1.1 | 3,388 | 3 |
| 2 | 2,823 | 61.6 | 19.8 | 8,470 | 59 |
| 3 | 791 | 38.8 | 8.7 | 2,372 | 26 |
| 4 | 97 | 8.4 | 1.6 | 290 | 5 |
| 5 | 0 | 0.0 | 0.0 | 0 | 0 |
| 6 | 0 | 0.0 | 0.0 | 0 | 0 |
| Total | 4,840 | 115.0 | 31.2 | 14,520 | 94 |
| Ave BD | 2.0 | | | | |
| | Culms/Clump | | 12.9 | | |

| Merrick - 27 Acres; 3-years-old | | | | | |
|---------------------------------|--------------------|-------------|-------------|-----------------|------------|
| 2022 in June | | | | | |
| Culm | -----Per Acre----- | | | -----Total----- | |
| | BD | Culms | BA | Fiber Tons | Culms |
| 1 | 2,881 | 15.7 | 2.9 | 77,795 | 78 |
| 2 | 2,223 | 48.5 | 15.6 | 60,031 | 420 |
| 3 | 210 | 10.3 | 2.3 | 5,666 | 62 |
| 4 | 6 | 0.5 | 0.1 | 153 | 3 |
| 5 | 0 | 0.0 | 0.0 | 0 | 0 |
| 6 | 0 | 0.0 | 0.0 | 0 | 0 |
| Total | 5,320 | 75.0 | 20.8 | 143,646 | 563 |
| Ave BD | 1.5 | | | | |
| | Culms/Clump | 14.2 | | | |

| MFA- 10 Acres; 3-years-old | | | | | |
|----------------------------|--------------------|-------------|-------------|-----------------|------------|
| 2022 in June | | | | | |
| Culm | -----Per Acre----- | | | -----Total----- | |
| | BD | Culms | BA | Fiber Tons | Culms |
| 1 | 3,573 | 19.5 | 3.6 | 35,733 | 36 |
| 2 | 2,493 | 54.4 | 17.4 | 24,928 | 174 |
| 3 | 153 | 7.5 | 1.7 | 1,531 | 17 |
| 4 | 9 | 0.7 | 0.1 | 85 | 1 |
| 5 | 0 | 0.0 | 0.0 | 0 | 0 |
| 6 | 0 | 0.0 | 0.0 | 0 | 0 |
| Total | 6,228 | 82.1 | 22.9 | 62,277 | 229 |
| Ave BD | 1.5 | | | | |
| | Culms/Clump | 16.9 | | | |

| HI Hat - 15.7 Acres; 5-years-old | | | | | |
|----------------------------------|--------------------|--------------|-------------|-----------------|------------|
| 2022 in June | | | | | |
| Culm | -----Per Acre----- | | | -----Total----- | |
| | BD | Culms | BA | Fiber Tons | Culms |
| 1 | 1,283 | 7.0 | 1.3 | 20,137 | 20 |
| 2 | 3,612 | 78.8 | 25.3 | 56,706 | 397 |
| 3 | 375 | 18.4 | 4.1 | 5,889 | 65 |
| 4 | 42 | 3.7 | 0.7 | 665 | 11 |
| 5 | 6 | 0.8 | 0.2 | 95 | 3 |
| 6 | 0 | 0.0 | 0.0 | 0 | 0 |
| Total | 5,318 | 108.7 | 31.6 | 83,492 | 496 |
| Ave BD | 1.8 | | | | |
| | Culms/Clump | 18.7 | | | |

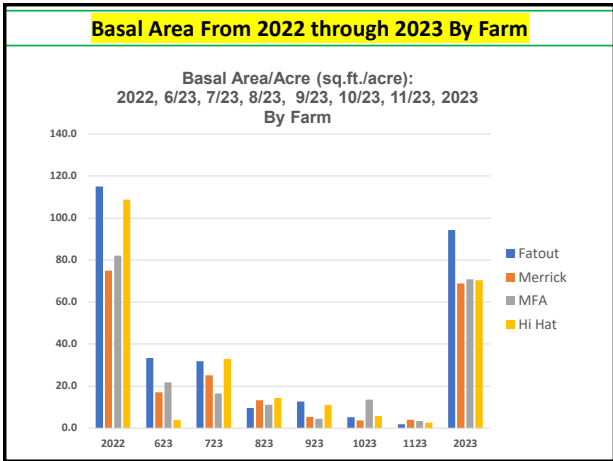
| Basal Area for Predicting Fiber and Food Yields | | | | | | | | |
|---|--------------------------|-------------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | 2022 Fiber Tons/BA | 2023 Food Tons/BA | | | | | | |
| | | June | July | August | Sept. | Oct. | Nov. | 2023 |
| Fatout | 0.2716 | 0.0302 | 0.0279 | 0.0311 | 0.0263 | 0.0326 | 0.0458 | 0.0294 |
| Merrick | 0.2779 | 0.0344 | 0.0386 | 0.0379 | 0.0396 | 0.0462 | 0.0397 | 0.0380 |
| MFA | 0.2782 | 0.0328 | 0.0385 | 0.0341 | 0.0351 | 0.0316 | 0.0314 | 0.0342 |
| Hi Hat | 0.2904 | 0.0322 | 0.0254 | 0.0320 | 0.0315 | 0.0368 | 0.0390 | 0.0295 |
| Mean | 0.2795 | 0.0330 | 0.0341 | 0.0357 | 0.0354 | 0.0362 | 0.0359 | 0.0328 |
| s | 0.0079 | 0.0043 | 0.0054 | 0.0055 | 0.0057 | 0.0058 | 0.0058 | 0.0041 |
| CV | 2.8 | 13.2 | 16.0 | 15.4 | 16.2 | 16.0 | 16.1 | 12.6 |

Basal Area/Acre Predicts Fiber and Food Yields

**2023 New Culm Inventory Summary
by Month (June-November) and Total for Four Farms**

**Culms Per Acre, Basal Area Per Acre (BA, ft²/acre),
Potential Food Green Tons Per Acre,**

**Total Culms, and Total Potential Food Green Tons By Month
and Total for 2023 by Basal Diameter (BD)**



9/8/23 Soil Properties - Basal Area Correlations

| Soil | Soil Properties By Farm | | | | New BAA | | | | | | | |
|------|-------------------------|---------|------|--------|---------|-------|-------|-------|-------|-------------|-------|-------|
| | Fatout | Merrick | MFA | Hi Hat | 2022 | 623 | 723 | 823 | 923 | 1023 | 1123 | 2023 |
| pH | 5.9 | 6.4 | 6.8 | 7.7 | 0.05 | -0.92 | 0.09 | 0.79 | -0.04 | 0.19 | 0.16 | -0.67 |
| CEC | 3.5 | 2.6 | 3.9 | 9.1 | 0.51 | -0.77 | 0.49 | 0.60 | 0.44 | -0.04 | -0.31 | -0.26 |
| P | 176 | 102 | 264 | 211 | 0.20 | -0.06 | -0.37 | -0.20 | -0.05 | 0.86 | -0.22 | -0.05 |
| K | 85 | 40 | 96 | 82 | 0.50 | 0.18 | -0.12 | -0.44 | 0.27 | 0.69 | -0.55 | 0.32 |
| Mg | 136 | 124 | 141 | 404 | 0.48 | -0.81 | 0.54 | 0.68 | 0.43 | -0.15 | -0.26 | -0.30 |
| Ca | 782 | 650 | 1253 | 2688 | 0.40 | -0.80 | 0.35 | 0.62 | 0.30 | 0.09 | -0.20 | -0.36 |
| B | 0.4 | 0.3 | 0.6 | 1.5 | 0.44 | -0.80 | 0.40 | 0.62 | 0.35 | 0.03 | -0.24 | -0.33 |
| Zn | 20.8 | 10.1 | 82 | 20.5 | -0.31 | 0.16 | -0.81 | -0.33 | -0.53 | 1.00 | 0.21 | -0.20 |
| Mn | 20 | 21 | 144 | 41 | -0.39 | 0.01 | -0.84 | -0.17 | -0.61 | 0.99 | 0.32 | -0.36 |
| Fe | 312 | 224 | 252 | 189 | 0.30 | 0.98 | -0.03 | -0.98 | 0.28 | 0.09 | -0.52 | 0.87 |
| Cu | 26.6 | 41.2 | 91.9 | 12.7 | -0.66 | 0.29 | -0.98 | -0.34 | -0.80 | 0.86 | 0.52 | -0.29 |
| Silt | 4.48 | 4.48 | 2.48 | 2.48 | -0.01 | 0.59 | 0.29 | -0.36 | 0.19 | -0.68 | -0.09 | 0.52 |
| K | 0.07 | 0.05 | 0.06 | 0.11 | 0.69 | -0.62 | 0.64 | 0.45 | 0.63 | -0.14 | -0.51 | -0.03 |
| OM | 0.58 | 0.5 | 0.58 | 0.93 | 0.56 | -0.73 | 0.53 | 0.57 | 0.49 | -0.07 | -0.36 | -0.20 |

2 Significant Soil - Basal Area Correlations

2023 Monthly Rainfall - Basal Area Correlations

| Date | Inches of Rain By Farm | | | | New BAA | | | | | | | |
|------|------------------------|---------|-------|--------|---------|--------------|--------------|-------|-------|--------------|-------|--|
| | Fatout | Merrick | MFA | Hi Hat | 623 | 723 | 823 | 923 | 1023 | 1123 | 2023 | |
| 523 | 4.11 | 0.27 | 2.37 | 0.66 | 0.85 | 0.04 | -0.95 | 0.43 | 0.26 | -0.71 | 0.88 | |
| 623 | 3.86 | 5.02 | 14.38 | 3.13 | | -0.95 | -0.30 | -0.73 | 0.94 | 0.44 | -0.31 | |
| 723 | 2.47 | 3.28 | 7.91 | 1.10 | | | -0.38 | -0.76 | 0.88 | 0.47 | -0.24 | |
| 823 | 9.87 | 4.86 | 6.81 | 9.11 | | | | 0.90 | -0.07 | -0.97 | 0.68 | |
| 923 | 4.96 | 14.45 | 9.83 | 1.58 | | | | | 0.05 | 0.81 | -0.37 | |

3 Significant Rainfall - Basal Area Correlations

| Basal Area Correlations | | | | | | | | | | | |
|-------------------------|-------------------------|---------|------|--------|---------|-------|--------------|-------------|-------|--------------|-------|
| Date | Basal Area/Acre by Farm | | | | New BAA | | | | | | |
| | Fatout | Merrick | MFA | Hi Hat | 623 | 723 | 823 | 923 | 1023 | 1123 | 2023 |
| 2022 | 115.0 | 75.0 | 82.1 | 108.7 | 0.11 | 0.79 | -0.24 | 0.97 | -0.27 | -0.97 | 0.70 |
| 623 | 33.3 | 17.1 | 21.8 | 3.8 | | -0.16 | -0.96 | 0.11 | 0.11 | -0.35 | 0.78 |
| 723 | 31.9 | 25.2 | 16.5 | 32.9 | | | 0.18 | 0.90 | -0.79 | -0.68 | 0.45 |
| 823 | 9.6 | 13.3 | 11.2 | 14.4 | | | | -0.18 | -0.29 | 0.47 | -0.80 |
| 923 | 12.6 | 5.4 | 4.4 | 10.9 | | | | | -0.50 | -0.93 | 0.71 |
| 1023 | 5.2 | 3.7 | 13.6 | 5.8 | | | | | | 0.19 | 0.19 |
| 1123 | 1.8 | 3.9 | 3.4 | 2.6 | | | | | | | -0.84 |
| 2023 | 94.3 | 68.8 | 70.9 | 70.4 | | | | | | | |

3 Significant Basal Area Correlations

Bamboo Productivity in FL:

Productivity Model Data:

Site + Preparation + Species + Genotype + Propagule
+ Planting Density + Site Amendments + Rotation (Age)
= PRODUCT YIELD(s)

Yield = f(Density, Site Index, Age)
Persistence Ratio

Forecasting Bamboo Production in Florida

Bamboo Economic Models

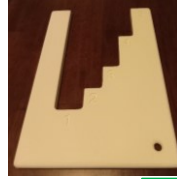
Cumulative Carbon Sequestration at Mean Annual Increment_{max}, MAI_{max} and Associated Rotation Age, and Land Expectation Value, and Associated Internal Rate of Return With and Without Carbon Credits for Bamboo Management Options

- Status of Florida Bamboo Inventory System**
1. Coordination – FBGA
 2. Collaboration with UF/IFAS and 4 growers
 3. Establishment of 31 permanent plots
 4. Preliminary fiber culm analyses: green weight equation, moisture content, field drying
 5. Initial measurement + 5 remeasurements
 6. Preliminary analysis: Plot and Sample (SI) size, stand and stock tables, etc.
 7. 2023 Report

Florida Bamboo Inventory System: Future Activities

1. Expand fiber culm analysis
2. Expand food culm analysis
3. 2024 and beyond remeasurements
4. Add 4 farms (~169 acres)
5. Preliminary yield model
6. Economics modelling

**Quantifying and Forecasting
Bamboo Production in Florida**



Thank you! Questions?

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