Defining Mixed Species Maximum Density
Technical Advisory Meeting
Spokane, WA
25 June 2014
The utility of the ‘normal’ stand as a reference

- Thinning meets numerous objectives:
  - Improved economic value
  - Increased resistance to wildfire, drought, pests and disease
- Thinning is prescribed based on a maximum reference density
- Typically define maximum density for single species
Progress on single species density models

- Modeled SDI$\text{max}$ for 4 species in the INW: DF, GF, PP, WL
- Based on IFTNC Database
- Developed Predictive layers
- Target species proportion always remains in models predicting maximum stand density

\[ \ln(TPA) = b_0 + b_1 \cdot \ln(QMD) + b_2 \cdot \text{RockType}_i + b_3 \cdot \ln(ADI) + b_4 \cdot \ln(Elevation) \\
+ b_5 \cdot \ln(\text{Prop. BA}) + b_6 \cdot \ln(\text{Prop. BA}) \cdot \ln(QMD) \]
The challenge of mixed species stands

- Mixed species stands are typical in the intermountain region
- Maximum density for mixed stands is difficult to define.
- But still necessary for management
Previous approaches to mixed-stand SDI\textsubscript{max}

- Weighted sums
- Lowest component
- Two-species conceptual model
- Difficult to model SDI\textsubscript{max} for all possible combinations
Proportion of the basal area (PBA) is always an important factor in single species models.

Shifts in Density by Factor

By subtraction, the PBA of other species in stand have equal and opposite impact.
Successional climax species have the greatest stocking potential

- Single species models predict greater SDI_{max} for the climax species than others
IFTNC Mixed Species Model

- Remove species filters
- Predict maximum density based on the entire IFTNC database
- Used as reference to compare single species models
Mixed stand likely have higher carrying capacity than pure stands

- More likely on PSME series than on ABGR series
- Predicted SDImax for mixed stands is more variable than for pure stands
Site quality effect are not greater than species effects

- Predicted SDImax for pine and Douglas-fir are similar on either veg series
- Yet there are strong species differences
- Variation in mixed stands is probably due to species mix rather than site variation
How do we determine SDImax for mixed stands?

• The all-species mixed stand model
  – is a lumped average
  – suggests individual species are important
• How to separate species in the mixed stand model?
  – Wood specific gravity approach
  – Multiple regression approach
Specific Gravity

SDImax is related to wood density

Table 2, Dean and Baldwin 1996 FEM 81:25
Potential mixed-species model

99th percentile of SDI for 26 specific gravity classes

$R^2 = 0.92$

119,235 FIA plots

Figure 3, Woodall et al 2005 FEM 216:367
Application of the specific gravity approach

Relative Density
RD = SDI / SDI_{max}

Where

SDI_{max} = 3547 – 3927 \text{ SG}_{mean}
4 of 13 specific gravity classes represent individual species
99th percentile of SDI for 13 specific gravity classes

Potential mixed-species model

IFTNC Database

101,443 plots

$R^2 = 0.97$
Stochastic Frontier Regression Model:

$$\ln(TPA) = \alpha + \beta_1 \ln(QMD) + \beta_{2,i} \times (Factors) + e$$

Proc QLIM in SAS

<table>
<thead>
<tr>
<th>Single-Species Factors</th>
<th>Mixed-Species Factors</th>
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<tbody>
<tr>
<td>• Basal Area</td>
<td>• Specific Gravity</td>
</tr>
<tr>
<td>• Rock Type</td>
<td>• Rock Type</td>
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<tr>
<td>• Elevation</td>
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<td>• SMRSPRPB</td>
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<tr>
<td>Specific Gravity</td>
<td>SDImax change (%)</td>
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The graph above shows the effect of specific gravity on SDImax. Specific gravity measures the density of a substance relative to water. In the context of this graph, it appears that specific gravity has a significant impact on SDImax, with specific gravity changes ranging from -100 to 0. The specific gravity value of 0 is associated with the highest SDImax change, indicating a positive relationship between specific gravity and SDImax.
Potential mixed-species model

Variation in mixed species model and specific gravity

- Modeled Average Specific Gravity
- Modeled Stand Type
- Estimated SDmax (TPA)
Addressing mixed species by including variables for each species

- DF BA ratio
- GF BA ratio
- PP BA ratio
- WL BA ratio
Maximum Stand Density Model Comparisons at 25% BA
Conclusions

• Forest site carrying capacity is essential for identifying management thresholds
• Species-specific size-density relations are available
• Half of Inland Northwest managed forest stands include more than one species
• Mixed-species size-density relations are not available
• Approaches used previously are summations, approximations or 2-species mixes
Conclusions

• Mixed species SDI{sub}max models were developed using IFTNC DB

• Mixed-species models are more variable than single species

• Variation in mixed species stands is likely due to range of species and sites included

• Average specific gravity of species mix holds promise for identifying SDI{sub}max on individual sites

• Properly implemented generalized model for mixed species may replace numerous single-species models
Validating SDI\textsubscript{max} models

- 99\textsuperscript{th} percentiles as proxy for SDI\textsubscript{max}
- Follow trend of density in long-term data
- Identify stands with a range of mortality rates
- Comparing FVS predictions to actual stocking while changing maximum density setting
99th percentiles as proxy for SDImax

- Species ranks remain consistent
- Magnitude is similar
- Under estimate SDImax for early seral species
99th percentiles as proxy for SDI\textsubscript{max}

- SS\textsubscript{I}max is highest at low BA ratios
- Tends to decline as one species becomes dominate
- Steepest decline is in WL and DF, shallowest for GF

![Graph showing the relationship between Basal Area Ratio and 99th percentiles of SDI. The graph includes lines for DF, GF, PP, and WL, indicating mixed and pure stands.](image)
Follow trend of density in long-term data

- Tree growth continues until carrying capacity is reached.
- Stressed trees succumb to various agents at imminent mortality through the self thinning line.
- Predicted SDI_{max} should exceed the zone of mortality.

Drew and Flewelling 1977
Rotation for different spacing