

Forest Inventory Growth & Yield

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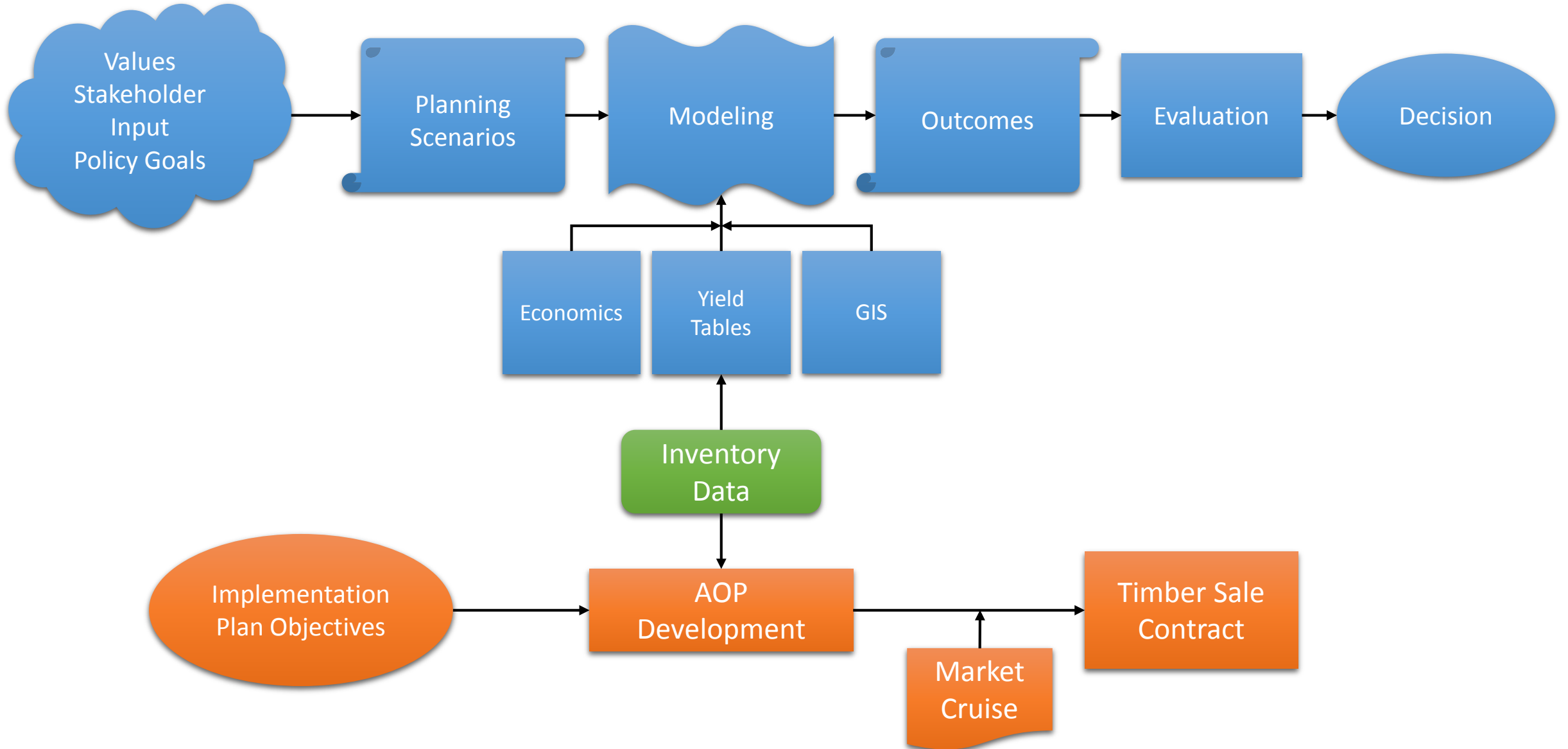
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April 26, 2017

Forest Inventory Concepts

- Relatively small samples are measured from larger populations
 - Plots measurement → Stand estimates → Forest estimates
- Updates to both data and methods are normal and ongoing
 - New plot measurements – field data collection
 - New stand boundaries – better GIS
 - Harvest depletions – completed timber sales
 - Improved growth and yield calibrations – modeling
 - Emerging technologies – Lidar
- ODF seeks to continually improve inventory data and methods of estimation

Forest Inventory – Planning & Operations



A Tale of Two Inventories

Operational and Planning

ODF currently uses inventory estimates for two different purposes:

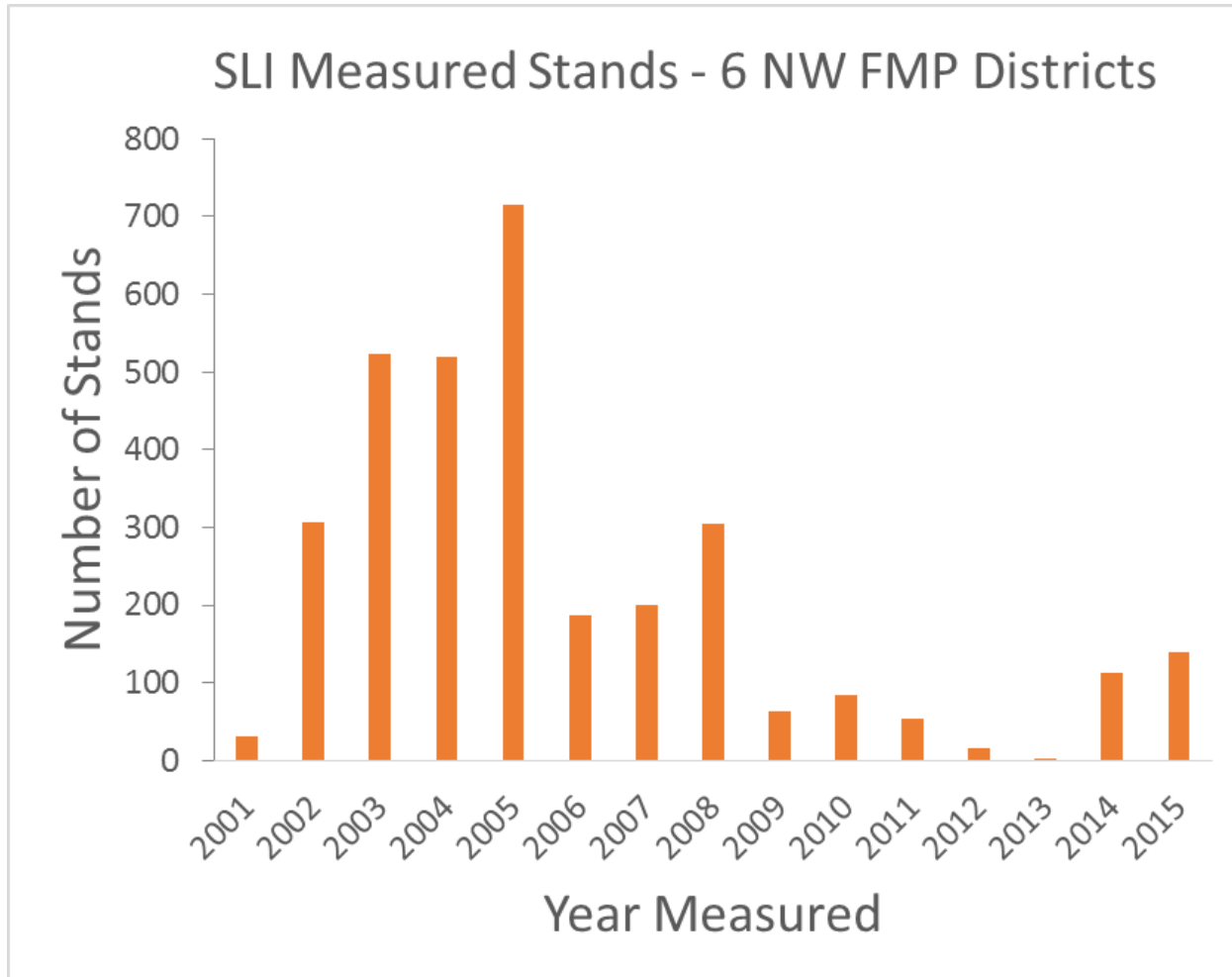
Stand Level Inventory (SLI)

- Developed to support NW FMP implementation (2001)
- Used to maintain and store current version of forest inventory data
- Updated annually with new plot measurement data
- Growth model: Forest Projection System (FPS)

Planning Inventory

- Developed to support Harvest and Habitat (H&H) project (completed 2006)
- Modeling inventory uses same base data as SLI
- Additional calibrations over time
- Growth model: Forest Vegetation Simulator (FVS)

Aging Inventory Data



- SLI began with intensive data collection
- Curtailed during Great Recession
- 32% of NW FMP area stands have measurements
- Over half of measured data is \geq 10 years old
- Only 7% of stands have measured data \leq 8 years old

Growth & Yield Contract

Need for Technical Assistance

- Different growth models (FPS vs FVS), additional calibrations and aging inventory result in two different inventory estimates.
- Two differing inventory estimates created confusion among stakeholders
- A stakeholder-sponsored Technical Expert Review Group (TERG) was formed to review ODF modeling practices
- TERG members highlighted a number of issues around ODF modeling, several of which were centered on growth and yield (G&Y)
- In response to TERG input and internal discussions, ODF requested proposals for technical assistance

ODF Request

- ODF selected a single growth model: FVS
- Recommendations tailored to FVS implementation
- ODF requested specific guidance to address:
 - Growth and mortality
 - Volume estimation and timber merchandizing
 - Genetic gain, disturbance and uncertainty
- ESSA Technologies was awarded the contract
 - ESSA staff is well versed and active in the FVS community

Contract Process

- ESSA investigated specific questions with ODF staff specialists
- Provided recommended methods, based on existing ODF data:
 - SLI data
 - Permanent plot sampling
 - Historic soils mapping
- Suggested future opportunities for enhancements
 - Site Index and growth increment sampling improvements
 - Reconciliation of inventory to actual harvest
 - Methods to evaluate future gains and uncertainty
- Interim report deliverables were shared with TERG stakeholders

State Forests Growth and Yield Modeling Recommendations

Don Robinson

April, 26rd 2017

ODF requested technical assistance on 6 key subject areas related to stand modeling:

1. **Site Index** – How is it estimated? What is the best use of existing data?
2. **Volume** – How is it used? Calculated? Can it be made more consistent?
3. **Calibration of FVS basal area multipliers** – What is the best way to use inventory data?
4. **Calibration of FVS Stand Density Index (SDI)** – What is the best way to use inventory data?
5. **Calibration of FVS for genetic gain & disturbance** – What is the best approach?
6. **Uncertainty** – What is the best way to include uncertainty in G&Y projections?

1 – Site Index (SI)

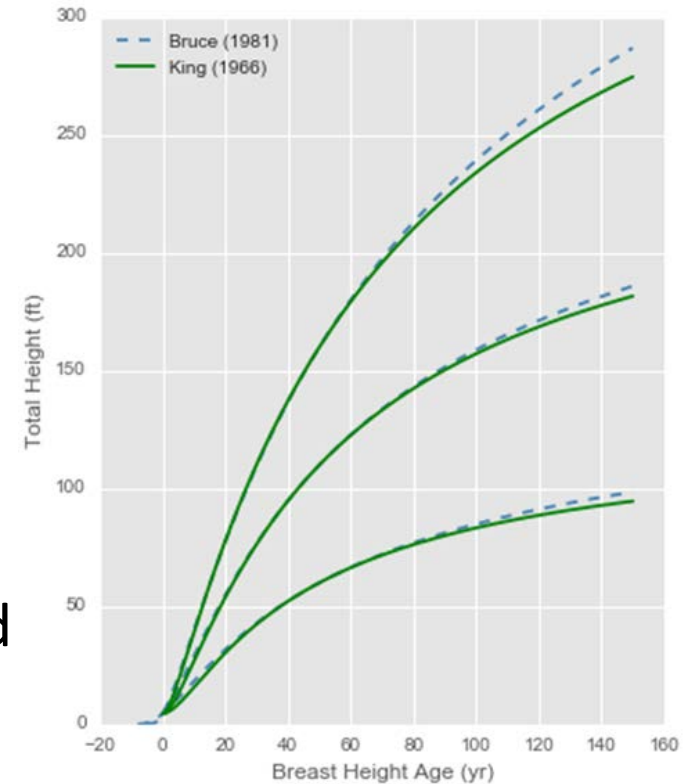
- The height of a stand of a given species at a standard age is a measure of long term potential productivity
- SI is used within FVS to adjust growth curves up or down for more- and less-productive stands
- ODF has two methods to estimate SI:
 1. **Soil-based** using maps which cover all the forest lands but have sources of uncertainty
 2. **Measurement-based** using trees from about 45% of ODFs 14,000 stands.
- The two methods don't agree exactly

1 – Site Index (SI)

- In measured stands, individual tree measurements are applied to standard curves based on pure stands of known age and height
- Multiple “standard” curves are available

Key recommendations

- Guidance for stands with very young and very old trees which may fall outside the appropriate age-range of the height-age SI curve
- Adoption of a standard “Bruce” curve for Douglas-fir
- New statistical analysis of relationship between soil-based and measurement-based SI
- More transparent calculation methods and better documentation



2 – Volume

- “Volume” means different things to different people
- There are different methods (and units and answers) for estimating tree volume, depending on the purpose or end-use of the tree
- Forest management has three main activities
 - **Stand management** – volume can be used to help to choose among treatment options
 - **Forest estate planning** – volume can be used to develop a sustainable harvest schedule; for measuring alternatives and benefits
 - **Timber sales** – volume can be used to estimate dollar value for harvested trees

2 – Volume

- A variety of operations (columns) support each forest management function (top rows) and measurements (bottom rows)

	Operations			
	Inventory	Growth & Yield	Timber Cruise	Scaling
Management Function				
Stand Management	YES	YES		
Forest Estate Planning	YES	YES	YES	
Timber Sales			YES	YES
Volume Measurement				
Total Volume (ft ³)	YES	YES		
Merchantable Vol (ft ³)	YES	YES	YES	YES
Scribner Board Foot (bd ft)	YES	YES	YES	YES

2 – Volume

Key recommendations

- Cubic foot volume estimates derived from the National Volume Estimator Library (NVEL) should be used for estate planning
- Scribner board foot volume estimates should be used for timber cruising using standard parameters (e.g. 32-foot and 40-foot log length)
- Changes to FVS volume calculations should be explored, to allow for Oregon standards incorporating more NVEL merchandizing options
- Standard volume methods should be established and documented, e.g. NVEL equations for cubic foot volume and parameters for board foot volume

3 – Calibration of FVS basal area multipliers

- Allow FVS to follow local growing conditions for each species, based on increment core data

Key recommendations

- Multipliers should be re-estimated after SI update is complete
- District-based multipliers are the right level of detail
- Modifiers for SNC are appropriate for regenerating stands in Tillamook District but should be re-estimated
- 2001 permanent plots are still valid but should be updated as resources allow
- Methodology for applying multipliers to un-inventoried stands should be documented

4 – Calibration of FVS Stand Density Index (SDI)

- SDI is a standardized way of describing stand stocking
- Maximum SDI is the maximum stocking that a stand can sustain before density-dependent mortality self-thins the stand

Key recommendations

- Maximum SDI should be reassessed with available inventory using the current version of FVS
- For estimating maximum SDI, stands used should be 80% pure and young trees should be excluded
- District staff should evaluate the difference between the new FVS variant (using Organon mortality) and the previous version, to decide which version is appropriate for the District

5 – Calibration of FVS for genetic gain & disturbance

- Genetic gain may improve growth
- SNC resistant stock should grow better in SNC regions

Key recommendations

- Assumptions about genetic gain can be explored with FVS simulations coupled to field studies
- SNC effects are already accounted for by basal area multipliers
- Endemic sources of disturbance should be included in silvicultural decisions
- Impact of episodic disturbances (e.g. wind events) can be included in simulation studies

6 – Uncertainty

- Can include natural variation, measurements, model (and others)

Key recommendations

- Uncertainty in timber productivity can be bounded by development of scenarios that account for main drivers: growth rate, SI, SDI and mortality
- Growth & Yield models tend to be optimistic: exploring range of outcomes is important
- Local calibration with inventory reduces regional variability

State Forests Growth and Yield Modeling Implementation

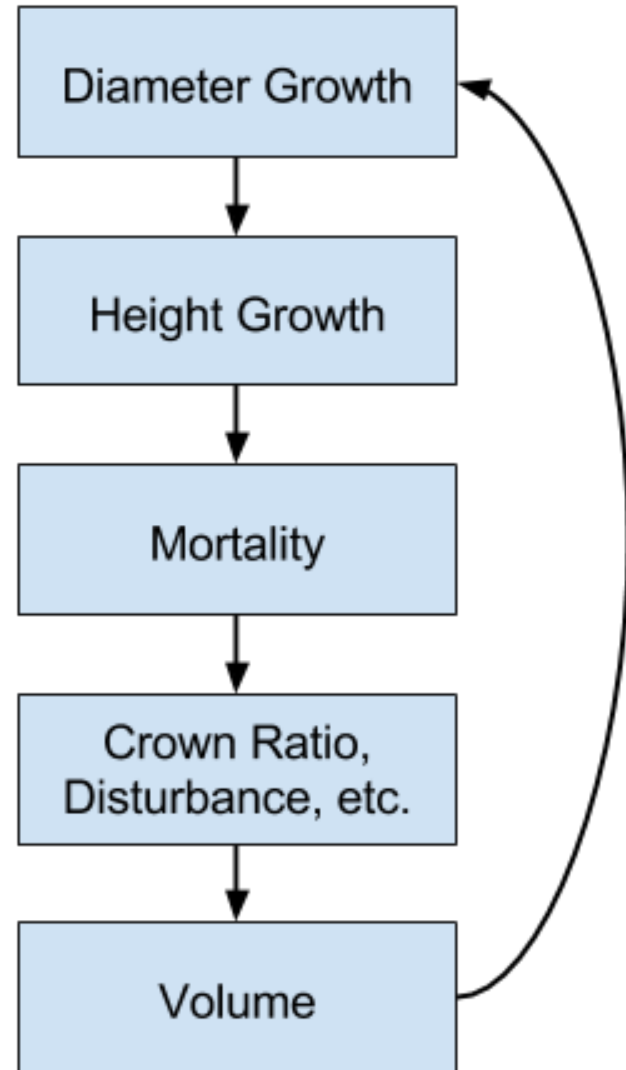
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ODF Implementation

- Implementation of key recommendations
- Field Review
- Update on current inventory

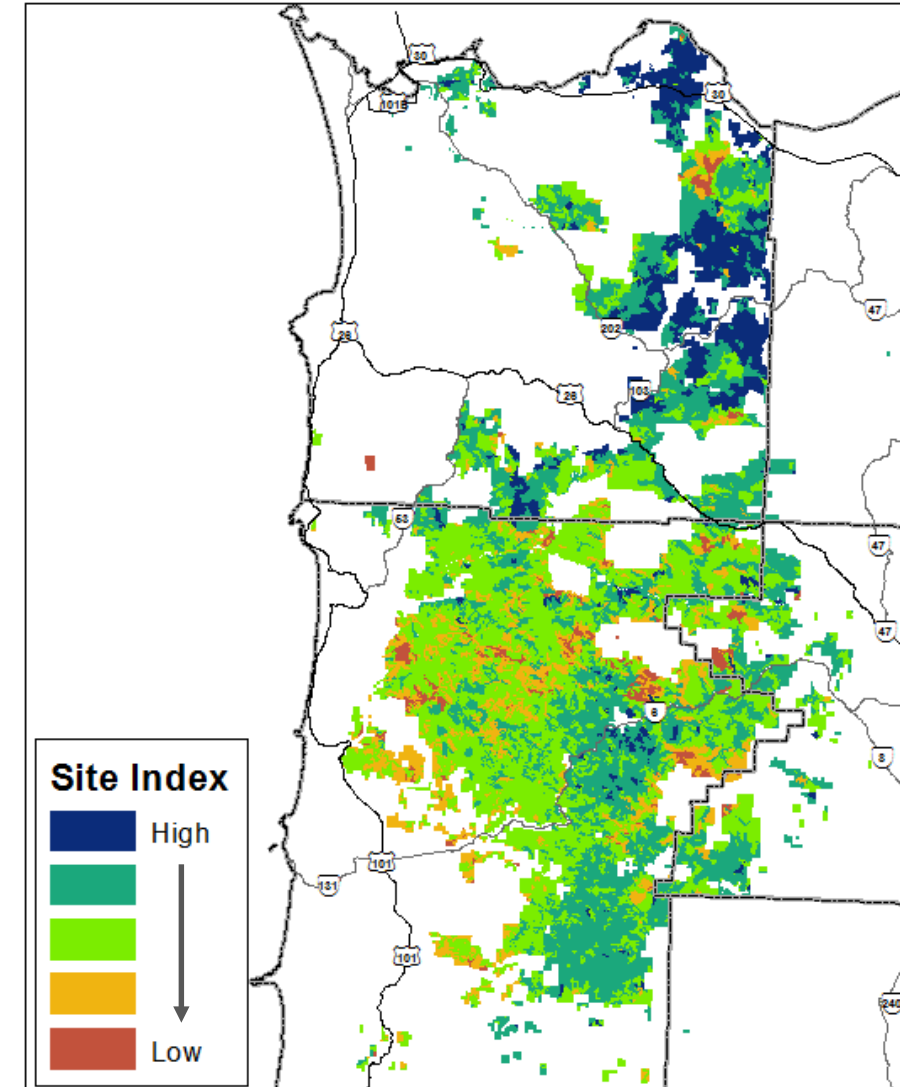
FVS Growth Cycle



ODF Implementation – Site Index

- ESSA Recommendation:
 - Use measured site index
 - Adjust soil based site index using a model
- ODF Implementation:
 - Site Index was calculated from SLI data
 - A model was developed to predict site index
 - Maps of site index produced for key species

Modeled Site Index



ODF Implementation – Volume Estimation

- ESSA recommendation:
 - Adopt a standard for volume estimation and merchandizing
 - Integrate cubic volume into reporting and analysis
- ODF Implementation:
 - Selected regionally appropriate volume estimators
 - Defined merchandizing specifications to be used for inventory estimates



➤ More work needed to understand local volume factors

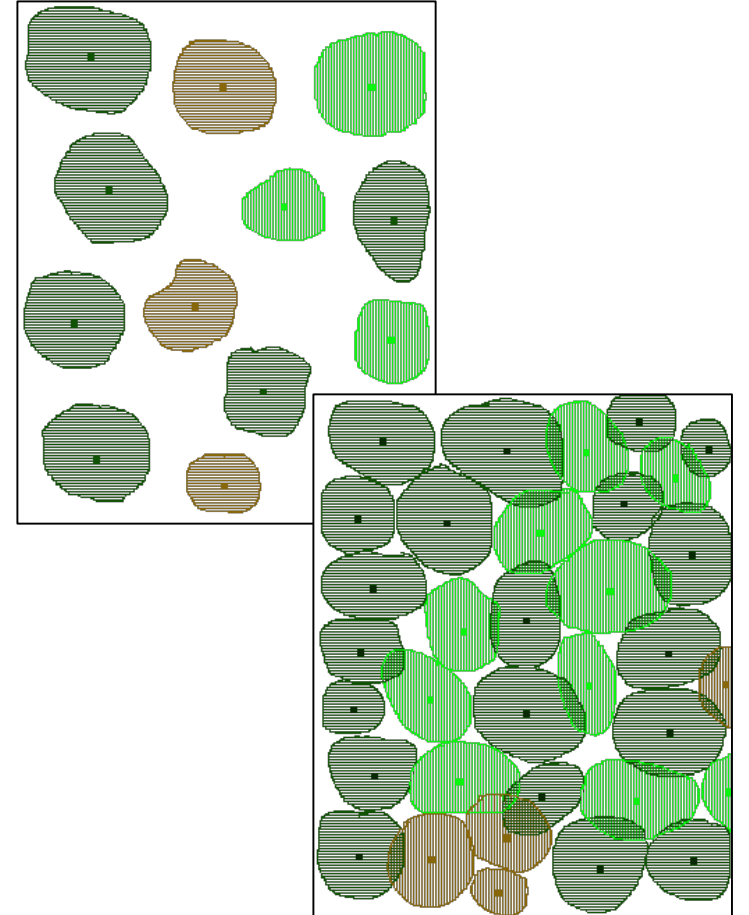
ODF Implementation – Basal Area Growth

- ESSA Recommendation:
 - Current methods are appropriate
 - Reanalyze using latest FVS revision following site index implementation
 - Collect more data where possible
- ODF Implementation:
 - Measured growth information was used from permanent plots
 - Calibrations were updated to reflect changes to site index and FVS
- Additional work needs to be performed to refresh the Swiss Needle Cast calibration for Tillamook



ODF Implementation – Stand Density Index

- ESSA Recommendation:
 - Use available inventory data to set max SDI
- ODF Implementation:
 - SDI limits evaluated from SLI data
 - Max SDI for key species
 - Douglas-fir
 - Western hemlock
 - Red alder
- Max SDI was last evaluated >10 years ago

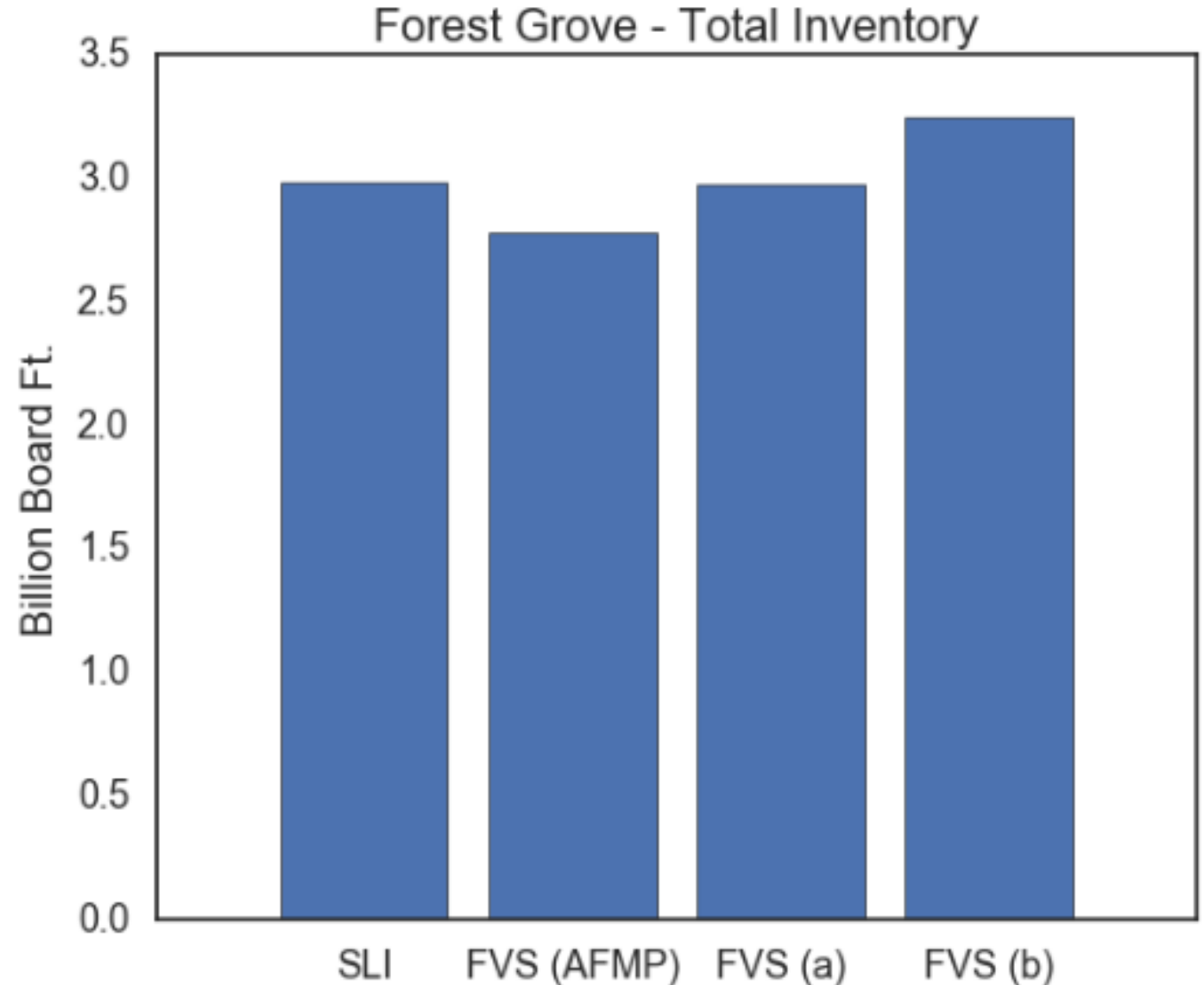


ODF Implementation

- G&Y Model Comparison

- SLI: Existing Method
- FVS (AFMP): Pre-ESSA
- FVS (a): Post ESSA
 - ❖ Excluding revised mortality
- FVS (b): Post ESSA
 - ❖ Including revised mortality

- The FVS mortality equations were revised in 2015.
- ODF will address mortality as resources allow.



ODF Implementation – District Review

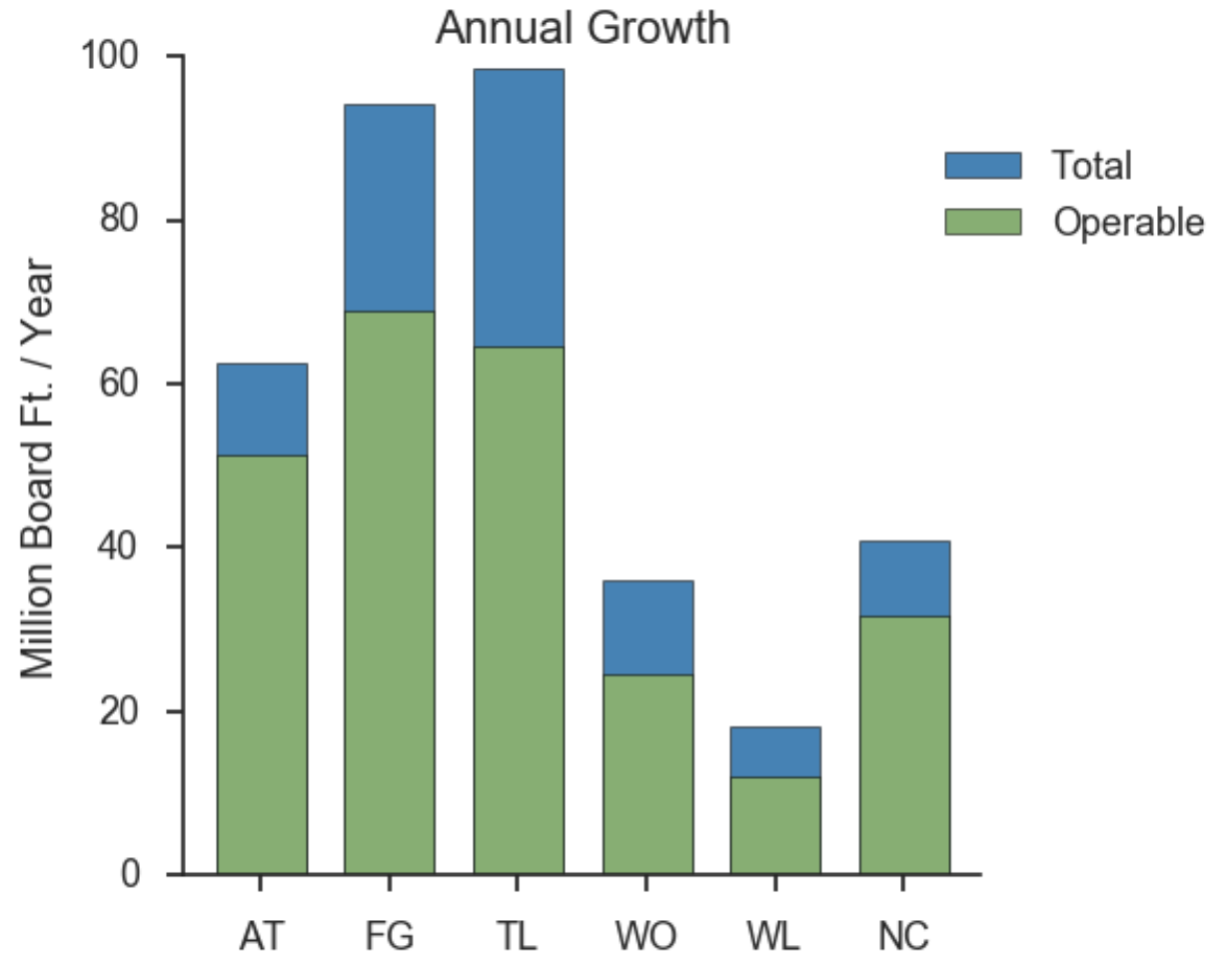
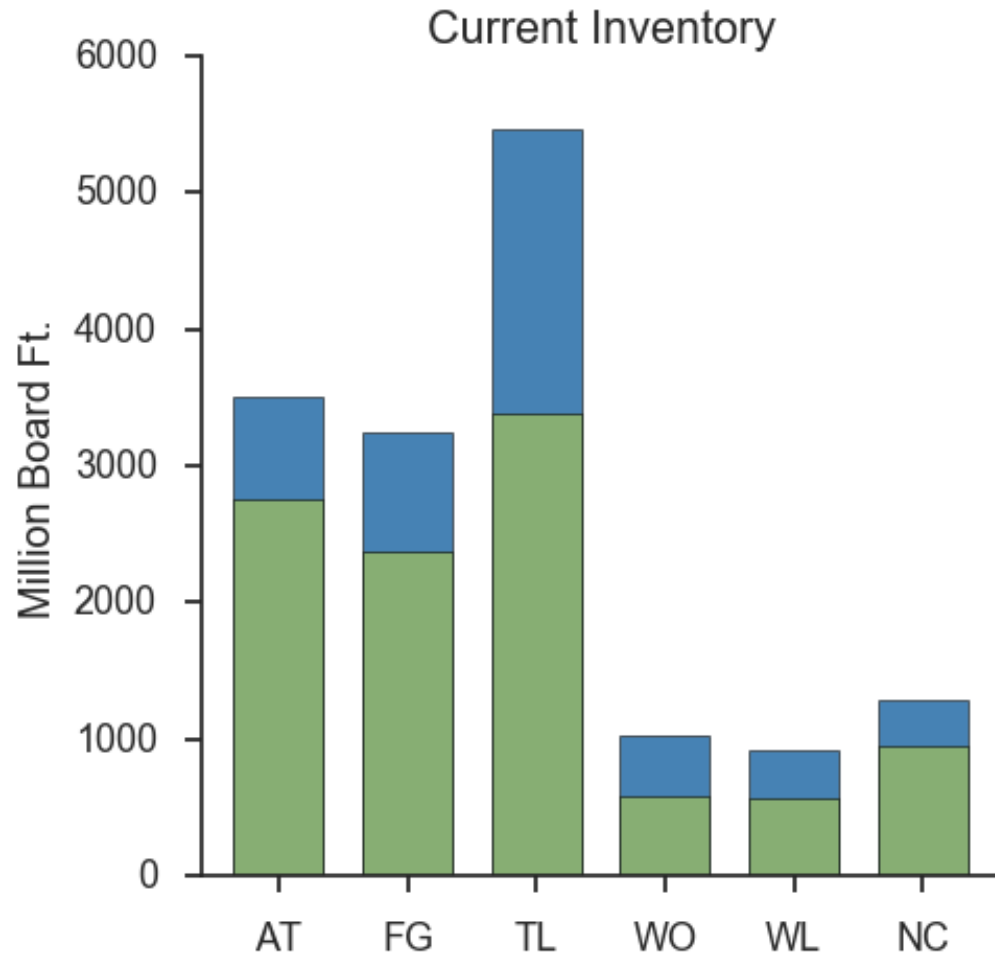
- Following consultation with ESSA
 - Review with district staff and adapt to local conditions
 - Randomized and blind to avoid reviewer bias
- 75 stands per district
 - Selected from broad categories of stands
- Three inventory estimates
 - SLI, FVS (a), FVS (b)
- District staff selected the estimate that best approximated the stand
 - Considered key inventory attributes
 - Merchantable volume
 - Stand density
 - Average diameter
 - Compared with cutout from nearby stands
 - Reviewed independent cruise data from similar stands
 - Lidar data - canopy ht. density, etc.
 - Used personal knowledge of stand conditions

ODF Implementation – District Review

- Results varied by district
- Tillamook and Astoria results indicated FVS(a) is best
- Inconclusive for other districts

	AT	FG	NC	TL	WL
FVS(a)	42	23	21	46	13
FVS(b)	12	25	29	3	11
SLI	21	26	25	26	19

ODF Implementation – Inventory Estimate



ODF Implementation – Inventory Estimate

District	Acres		Board Ft. Volume (mmbf)		Annual Growth (mmbf)	
	Net	Operable	Total	Operable	Total	Operable
Astoria	131,970	105,572	3,500	2,753	62.5	51.2
Forest Grove	111,711	82,972	3,249	2,374	94.2	69.0
North Cascade	46,057	34,605	1,282	946	40.9	31.7
Tillamook	246,264	160,529	5,472	3,379	98.4	64.5
Western Lane	24,702	16,499	914	570	18.2	12.0
West Oregon	35,422	23,133	1,020	577	36.0	24.5
<i>Combined</i>	<i>596,126</i>	<i>423,310</i>	<i>15,437</i>	<i>10,598</i>	<i>350.3</i>	<i>252.8</i>

- ❖ Acres exclude roads
- ❖ SLI Data as of June 2016

Operable Excludes:

- NSO Cores & best habitat
- MMMA
- Steep Slopes (Public Safety)
- Riparian Protections

Final Thoughts and Moving Forward

- There is no one agreed upon standard for estimating forest inventory, or for applying specific growth calibrations
- The methods for estimating forest inventory and projecting future growth have improved greatly and continue to evolve
- ODF is providing the best possible inventory estimate, based on methods that are suited to ODF's inventory data
- ODF has renewed SLI data collection efforts since 2014
- ODF will continue to pursue improvements as resources allow