

Validating IFTNC generated maximum stand density index models

Background, Validation, Application

Mark Kimsey 3/26/2013

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Background - Site Type Initiative

- Insects/Disease
- Fire
- Global Competition
- Forests must be managed to weather dynamic climate and economic conditions
- Knowledge of the physiographic factors responsible for forest health/productivity is critical



STI - In Brief

- Identify physiographic factors controlling forest carrying capacity (i.e., site quality)
 - Light, Moisture, Temperature, Nutrients
- Develop statistical models to estimate site quality based on controlling factors
- Create regional, geospatial GIS tools that predict forest site quality



Quantifying Site Type

- Most common forest measures of site quality
 - Annualized growth rates
 - Site Index Height growth as a function of species and time
 - Volume Production Unit of biomass produced periodically
 - Difficulties:
 - Requires height/age pairs on suitable site trees
 - Requires repeated measures where all trees on the plot are sampled for height



Stand Density Index

- For a given average tree size, there is a limit (maximum) to the number of trees per acre that may coexist in a stand
- Independent of Age and Height
- Requires basic cruise data
- We hypothesize that Max SDI can be used as a measure of site quality



Utility of Stand Density Index

- % of max SDI an index of intratree competition for site resources
- Shifts in the slope & intercept reflect changes in site carrying capacity site quality?
- Used to define upper and lower limit management zones
- Cohcran & Powell developed spacing and stocking guidelines by species and plant communities



STI Database



<u>Dataset:</u> >150,000 plots 4+ million trees 28 tree species

Associated Input: 100 variables: stand/tree level, climate, geology, topography

Cooperator Data Suppliers:

USFS-FIA/CVS, BLM, WA DNR, IDL, Forest Capital, Stimson, Hancock, Inland Empire Paper, Bennett Lumber

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SDI: Inland Northwest Forests



Green line = Inland NW maximum biological carrying capacity

Self thinning line slope statistically the same to Reineke's (1933) slope of -1.605

Max SDI (TPA) is indexed to a QMD of 10 inches

Max SDI = 628 TPA

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Modeling the Self Thinning Line

- QUESTIONS: How does this average curve (line) change by species, rock type, site factors, topography and climate variables?
- The impact of a variety of covariates on the <u>species</u> self-thinning boundary intercept and slope was examined:
 - Rock type and Stand factors (proportion of BA of the predominant species, Skewness of DBH^{1.5} distribution)
 - Climate/Topography factors



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Modeling Max SDI: Stochastic Frontier Regression

- Ranked in proportion of influence:
 - Proportion of species basal area
 - Pure species stands will have the highest max SDI potential
 - Elevation
 - Integrates effects of temperature and precipitation
 - Annual Dryness Index
 - Ratio of Degree Days>5C to Mean Annual Precipitation
 - Rock Type
 - DF: Extrusive>Sedimentary>Glacial>CaMetased>Metased>Intrusive
 - Cosine of Aspect
 - North South aspect (Latitudinal effect)

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Species Max SDI Models - Douglas-fir

SDImax = f(QMD, Aspect, Annual Dryness Index, Elevation, Species Basal Area, Rock Type)



Validation

IFTNC Long-Term Research Plots FVS projection analyses

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Validation Stands - North Idaho

Site	Age	TPA	QMD	BA	SDI	VS/HT	ΡΜ
DF Site 255	34	660	7.3	190	395	ABGR/CLUN	ASH/GNEISS
DF Fert/Thin	30	663	6.4	147	323	ABGR/CLUN	ASH/SCHIST
DF Site 254	27	600	5.2	89	212	THPL/CLUN	ASH/BASALT



Determining Max SDI

- Modeling density dependent mortality requires accurate estimates of max SDI
- Forest Vegetation Simulator estimates max SDI as a function of Habitat Type and basal area maximum (depending on variant)
- Reineke (1933) and Long (1985) estimate max SDI at ~ 590 for Douglas-fir (WA-OR)
- IFTNC max SDI estimates are continuous across the landscape

	FVS	Reineke	IFTNC
Site 255	820	590	412
Fert/Thin	820	590	440
Site 254	949	590	473

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% Max SDI by Site & Source

Free	Max Ind.	Max Stand	Low-Mod	High
Growth	Growth	Growth	Mortality	Mortality
0-25%	25-35%	35-60%	60-80%	80-100%

	Observed SDI		FV % Ma	'S x SDI	Reinel SDI % Max S		IFTNC I % Max SD	
Site	Begin	End	Begin	End	Begin	End	Begin	End
Site 255	395	449	48%	55%	67%	76%	96%	109%
Fert/Thin	323	363	39%	44%	55%	62%	73%	83%
Site 254	212	343	22%	36%	36%	58%	45%	73%

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FVS Projected Mortality by Site & Source

	Observed FVS		Reineke	IFTNC
Site		Mortality (ft ³ ac ⁻¹ yr ⁻¹)	
Site 255	79	50	61	76
Fert/Thin	48	22	31	48
Site 254	0	11	13	16

Dataset Validation Summary

- Default max SDI values in FVS significantly underestimate density dependent mortality
- IFTNC max SDI estimates more realistic, but need further testing across the region
- We need cooperator feedback on how species max SDI estimates work in your region
- Suggestions for improvement welcome

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Field Validation

- IFTNC max SDI estimates can be generated in the field
- Pocket Excel macro integrates stand cruise data and max SDI equations
- Projects stand % max SDI
- Thinning scenarios generated on the fly based on stand % max SDI



Field Validation

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3	Parameter	Estimate	cruise	control	Light Thin	Heavy Thin				
4	Intercept	12.957	12.957	12.957	12.957	12.957 🔳				
5	CaMetased	-0.063	-0.063	-0.063	-0.063	-0.063				
6	QMD	-1.716	8	8.55	9.35	9.6				
7	Aspect	0.074	50	50	50	50				
8	ADI	-0.398	0.21	0.21	0.21	. 0.21				
9	Elevation	-0.524	4300	4300	4300	4300				
10	PBA	-1.08	0.81	0.68	0.67	0.67				
11	QMD*Elevation	0.074	17.40	17.95365576	18.70198625	18.92274762				
12	QMD*PBA	0.281	-0.44	-0.827605182	-0.895218078	-0.905785382				
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Field Validation

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3	2	280	6.39	71.86	6.86	0.07	153.20	36			
4	3	380	9.41	213.42	10.15	0.24	389.02	90			
21	21	500	6.87	146.94	7.34	0.90	304.89	71			
22	22	500	5.89	121.45	6.67	0.21	261.78	61			
23	23	500	6.08	122.03	6.69	0.71	262.78	61			
24	24	300	8.32	126.74	8.80	0.42	244.55	57			=
25	25	380	8.88	189.57	9.56	0.29	353.83	82			
26		366	7.35	124	7.93	0.53	248	58			
27											
28	PLOT	TPA	Spacing	%mSDI							
29	CONTROL	366	11	58							
30	LIGHT THIN	222	14	36							
31	HEAVY THIN	134	18	22							-
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Preliminary Field Assessment

• Four Paired Plot Density Management sites installed summer 2012

 All stands fell between 50 and 75% of IFTNC estimated max SDI

 Stands >60% max SDI showed density related mortality

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Current IFTNC Max SDI Projects

Paired-Plot Density Management Study



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Wildland Fire Science Partnership Validating FVS max SDI



Summary

- Max SDI is strongly dependent on site type – not species alone
- Species specific max SDI models provide improved mortality estimates over the FVS Inland Empire variant
 - Needs to be tested against other INW variants
- Additional testing is necessary to validate site type effects on max SDI – i.e., Paired Plot Study
- Model improvements require feedback from cooperators





Feedback!

Mark Kimsey Intermountain Forest - Tree Nutrition Cooperative University of Idaho Moscow, ID 83844 (208) 885-7520 <u>http://www.cnr.uidaho.edu/iftnc/</u>



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