

Kispiox TSA Young Stand Monitoring Program

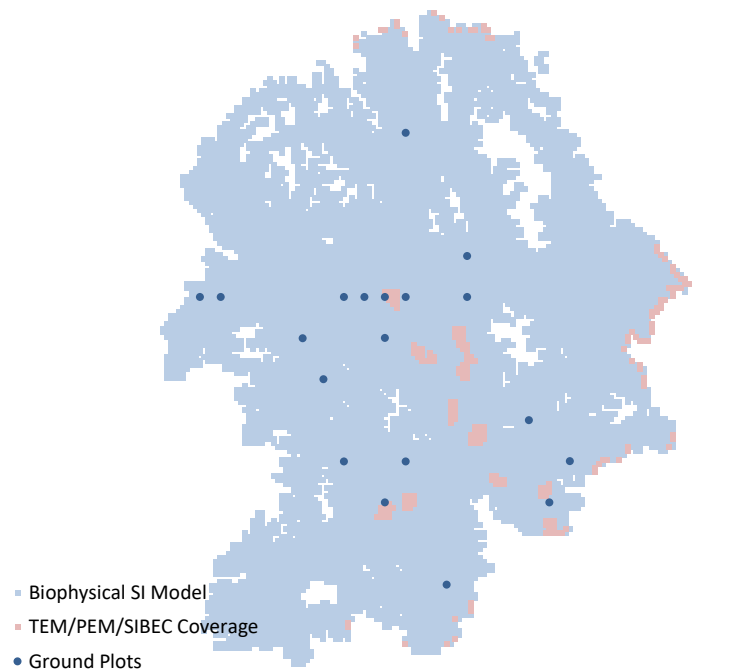
Overview

Young Stand Monitoring (YSM) programs have been established across a number of management units in BC. This handout provides a high-level technical summary of results compiled by FAIB for the Kispiox TSA YSM.

The target population for TSA-based monitoring programs includes Crown 15-50 year old forested stands defined by the Vegetation Resources Inventory (VRI) rank 1 layer. Licensee's TFL-based monitoring programs generally use other population criteria.

Ground samples (dots on map, right) are established on a 5 X 10 grid, with trees tagged in 0.04ha permanent plots and planned for periodic re-measurements.

Some key YSM objectives are to: describe the characteristics and structure of young stands, report on forest health, assess the accuracy of predicted attributes, and compare against growth models to help evaluate if young stands will meet future timber supply expectations.



Meas	# Ground Samples by Year (end of growing season)	
#	2017	Total
0	19	19

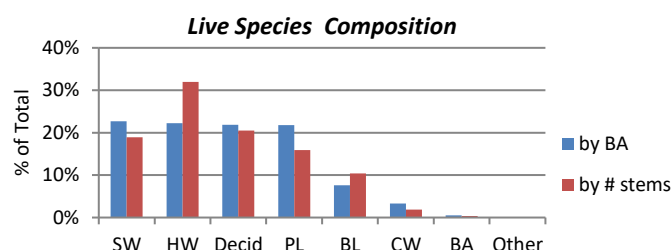
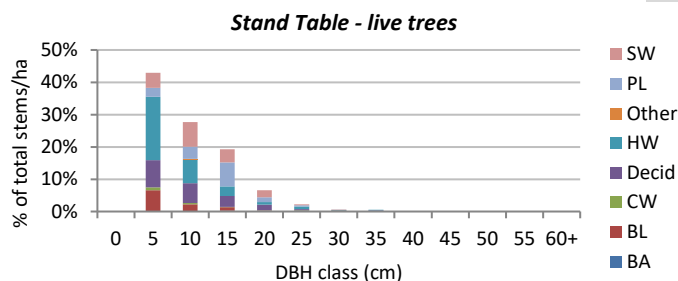
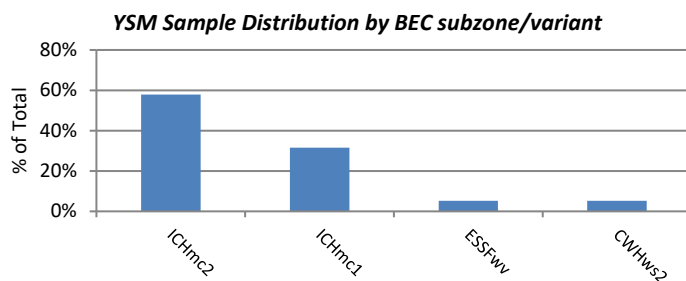
Summary of Key Findings for Existing Young Stands in the Kispiox TSA related to Timber Supply

1)	The leading species from YSM ground samples is compared to the interpreted leading species in the VRI forest cover inventory. The leading species percent agreement is :	42%	(% agreement)
2)	Species composition from YSM ground samples is compared to RESULTS opening records (used for modeling existing managed stands in TSR). The overall species composition overlap is:	73%	(% of stems/ha)
3)	The Provincial Site Productivity Layer (PSPL, used for modeling existing managed stands in TSR) is assessed for bias using YSM ground based site index data. Site index bias (in percent) is listed by species if significant, where a positive percent is an under-estimate in the PSPL, and a negative percent is an over-estimate:	None	
4)	YSM samples plus TASS projections of YSM samples both include conifer and deciduous tree species. The deciduous proportion in the YSM samples (% of total volume) is :	22%	(% of m3/ha)
5)	YSM samples plus TASS projections of YSM samples include the separate tracking of both managed vs. residual cohorts. The residual proportion in the YSM samples (% of total volume) is :	0%	(% of m3/ha)
6)	The periodic annual increment (PAI) of TSR MSYTs are compared against re-measured YSM samples over the same remeasurement period, to test if TSR projections are significantly different :	NA	
7)	The PAI of the YSM TASS projections are compared against re-measured YSM samples over the same remeasurement period, to test if TSR projections are significantly different :	NA	
8)	For YSM samples measured since 2017, the forest health impact from stem rusts is directly modeled in YSM TASS projections using GRIM / CRIME. The projected volume impact of stem rusts by age 100 is :	0.7%	(% of m3/ha)
9)	For selected forest health agents expected to cause short term mortality, a simplistic method is used to approximate a future impact in YSM TASS projections of :	3.1%	(% of m3/ha)
10)	For selected forest health agents expected to cause incremental mortality, a simplistic method is used to approximate a future impact in YSM TASS projections (reported at age 100) of :	1.0%	(% of m3/ha)
11)	TSR MSYTs are compared against YSM TASS projections, to test if TSR assumptions will meet future expectations of YSM stands grown to rotation. Reported are the maximum percent difference of TSR volume relative to YSM (a negative % is where TSR is lower than YSM, positive % is where TSR is greater than YSM); the projected age this occurs at; and a test if the differences between the two is significant.	Max % vol diff Age @max vol diff Significant? TSR bias?	-13% 60 No No

Young Stand Description

Stand summaries (all species combined) are compiled and summarized for all samples in the target population at latest measurement. Compilations are for all standing trees ≥ 4 cm DBH, except net merchantable volume (ie., PL ≥ 12.5 cm DBH, & all other species ≥ 17.5 cm DBH, excluding 30cm stump height, 10cm top diameter, & decay). Species code names are listed on page 5.

	n	Live				Dead
		Avg	Min	Max	SD	Avg
Basal Area (m ² /ha)	19	25.6	3.2	47.8	12.4	0.6
Total Stems (#/ha)	19	2,375	150	5,579	1,371	58
Quadratic Mean DBH (cm)	19	11.7				11.0
Whole Stem Vol. (m ³ /ha)	19	153	13	462	117	3
Net Merch Vol. (m ³ /ha)	19	81	3	385	92	1
Total age all site trees (yrs)	38	35	18	55		



Species Composition Compared against Forest Cover Inventory & RESULTS

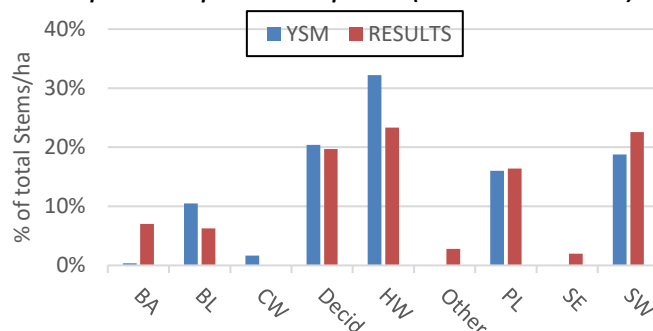
Leading species (by basal area) is compared between YSM & the VRI Inventory where the 'correct leading species classification rate' is a percent of all YSM samples with matching inventory leading species (table left). Overall species composition (by stem count) is also compared between YSM and RESULTS Opening ID data (table right). The planted & natural stem counts from RESULTS data are combined to compare overall species composition overlap between YSM and RESULTS.

Leading species cross-table comparison (sum of the # of YSM plots)

YSM						
VRI	BL	Decid	HW	PL	SW	Total
BA					1	1
BL	1					1
Decid			1	2	1	4
HW		1	2	1		4
PL			2	2	1	5
SW		1			3	4
Total	1	2	5	5	6	19

Correct Leading Species Classification Rate = 42%

Species Composition Comparison (based on stem count)



Overall Species Composition Overlap = 73%

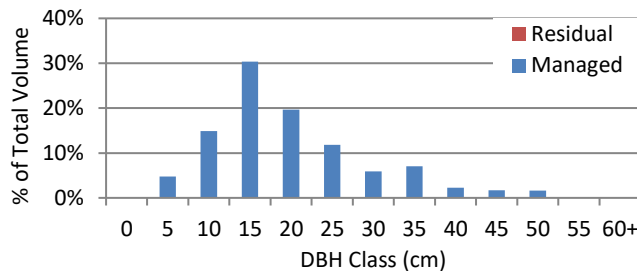
Site Index vs. Provincial Site Productivity Layer

Site index (SI) is an estimate of a stand's potential productivity by species. Predicted SI is from the Provincial site productivity layer (PSPL v7.0), using ecological mapping plus SIBEC tables (or SI biophysical model when no ecological mapping is available), from a spatial overlay of the PSPL with YSM locations. YSM ground SI is from an average of four suitable site trees per species from each YSM sample. The average and ratio of means (ROM) are computed from the paired SI estimates (table right). PSPL underestimates SI when ROM >1 , and overestimates SI when ROM <1 . Ratios are highlighted in red when significant (@ $\alpha=0.05$). Note the overview TSA map illustrated on page 1 also highlights the area coverage by TEM/PEM & SIBEC (pink) vs. Biophysical model (blue).

Spc	#Pairs	YSM BH Age (yr)			SI (m)		ROM	Sig (95%)
		n	Avg	Min	Max	YSM	PSPL	
BL	5	30	19	40	18.9	18.9	1.00	N
EP	6	32	27	44	20.8	20.1	1.04	N
HW	11	32	14	49	20.4	19.9	1.02	N
PL	7	22	13	35	22.4	22.4	1.00	N
SW	9	25	12	47	23.5	22.4	1.05	N

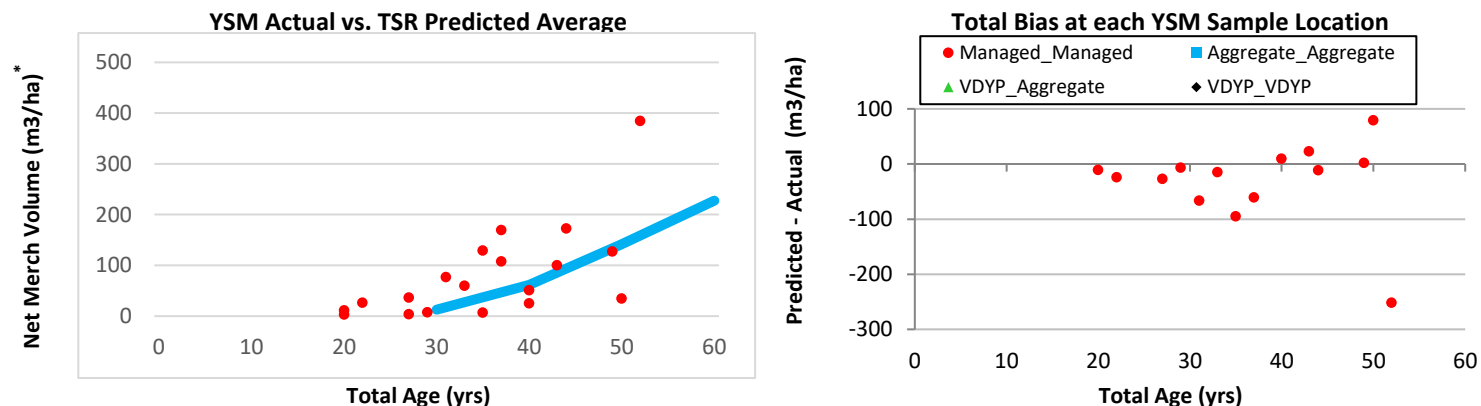
Post-Harvest-Regenerated vs. Residual Trees

Young stands may include older residual trees which have important ecological, management, and growth implications. Residual trees are identified in the field using standard measurement protocols. Depending on analysis, it may be necessary to separate the residual from post-harvest-regenerated trees in young stands. The contribution of the residual cohort in the measured YSM samples is reported (chart, right).



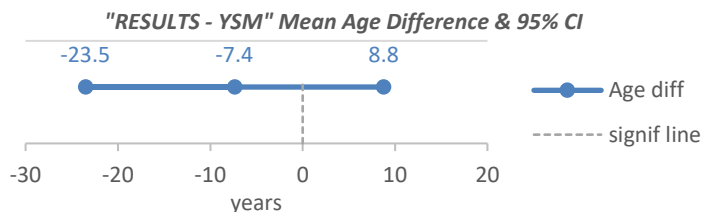
Comparing Current Volumes: TSR Predicted Yield Tables vs. YSM Actual Measurements

YSM volumes are compared to both existing managed (MSYT) and existing natural (NSYT) stand yield tables developed for FAIB's timber supply review (TSR) analysis. For YSM locations modeled in TSR as managed, MSYTs are from TIPSy ver 4.4 using "RESULTS" Silviculture Opening records spatially matched to each YSM sample location, or using aggregate inputs where RESULTS data are not available. For YSM locations modeled in TSR as unmanaged, NSYTs are from VDYP ver 7 using VRI inventory rank1 attributes. TSR predicted volumes are compared to YSM volumes using RESULTS age adjusted to the year of ground sampling (or VRI VEGCOMP adjusted age when no RESULTS data exist). The left graph plots YSM actual volume (points are joined where re-measurements are available), plus the average of all spatially intersected TSR existing yield tables (solid blue line). The right graph illustrates the total bias (predicted minus actual volume) at each individual YSM sample location. TSR predicted volumes underestimate current YSM volume when the bias is negative, and overestimate current YSM volume when positive.



Test to Compare RESULTS Total Age vs. YSM Ground Sample Age

TSR uses the RESULTS age (or VRI age when no RESULTS data are available) as the starting age in timber supply forecasts. This reference age (adjusted to the year of ground sampling) is also used to match the predicted yield table volume with a YSM volume at each sample point location. T-tests of the paired age differences (RESULTS - YSM) provides a check for significant differences between RESULTS and YSM ages (highlighted when significant @ alpha=0.05, table right). Note that YSM sample tree ages may include a combination of both managed and (sometimes) older residual cohorts based on the sample tree data collection criteria.



Age Source	# obs	Mean Age	P-Value of Age Diff
RESULTS	19	35.3	0.350
YSM	19	42.7	

RESULTS summary by Regeneration & Genetic Worth

YSM sample locations are intersected with RESULTS opening IDs to summarize average regeneration type and genetic worth used as TSR MSYT inputs (tables right). YSM samples spatially joined with an existing RESULTS opening ID are summarized separately from those without opening ID's and hence joined to an aggregated MSYT input estimate.

Regeneration Type			Species Genetic Worth %	
	Opening id	Aggregate	Opening id	Aggregate
Planted	35%	0%	PL	0.6
Natural	65%	100%		

Components of Change : Re-measured YSM Samples

Growth and mortality of the (n=0) re-measured YSM ground samples are summarized into components of change, for all tagged trees over an average period of - years (figure right):

Survivor Alive at both measurements

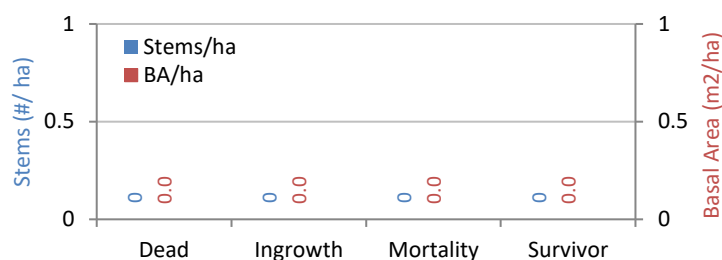
Ingrowth Exceeds minimum tagging limits at last measure

Mortality Died inbetween measurements

Dead Dead standing at both measurements

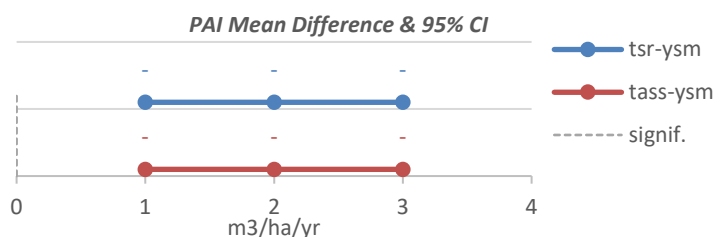
Not reported as fewer than 5 YSM re-measurements completed to date.

Components of Change



Test to Compare Modeled vs. YSM Re-measured Periodic Annual Increment

Periodic annual increment (PAI) in units of m3/ha/yr, is computed from all re-measured YSM ground samples, and compared against predicted PAI from TSR yield tables, as well as from YSM TASS projections over the same YSM re-measurement period. T-tests of the paired difference checks for significant differences in PAI (highlighted when significant @ alpha=0.05, table right).



YSM vs. TSR MSYTs			
attr.	# obs	Yrs	PAI
YSM	-	-	-
TSR	-	-	-

YSM vs. TASS projections			
attr.	# obs	Yrs	PAI
YSM	-	-	-
TASS	-	-	-

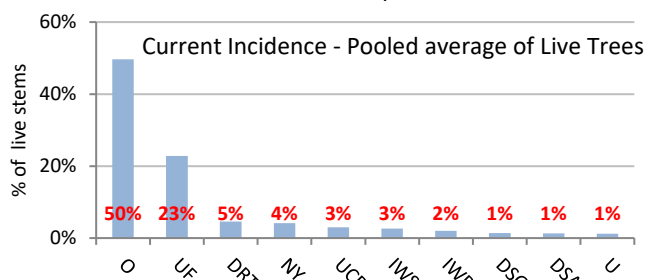
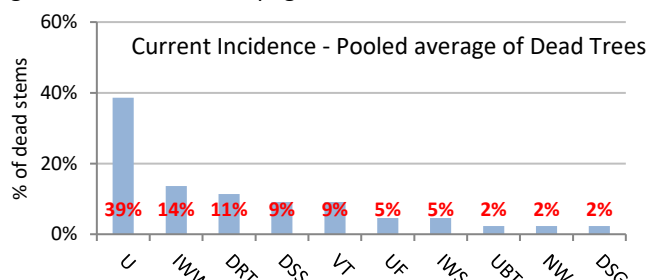
TSR-YSM diff (m3/ha/yr)			
p-val	Diff	L95	U95
-	-	-	-

TASS-YSM diff (m3/ha/yr)			
p-val	Diff	L95	U95
-	-	-	-

Not reported as fewer than 5 YSM re-measurements completed to date.

Current Forest Health Incidence

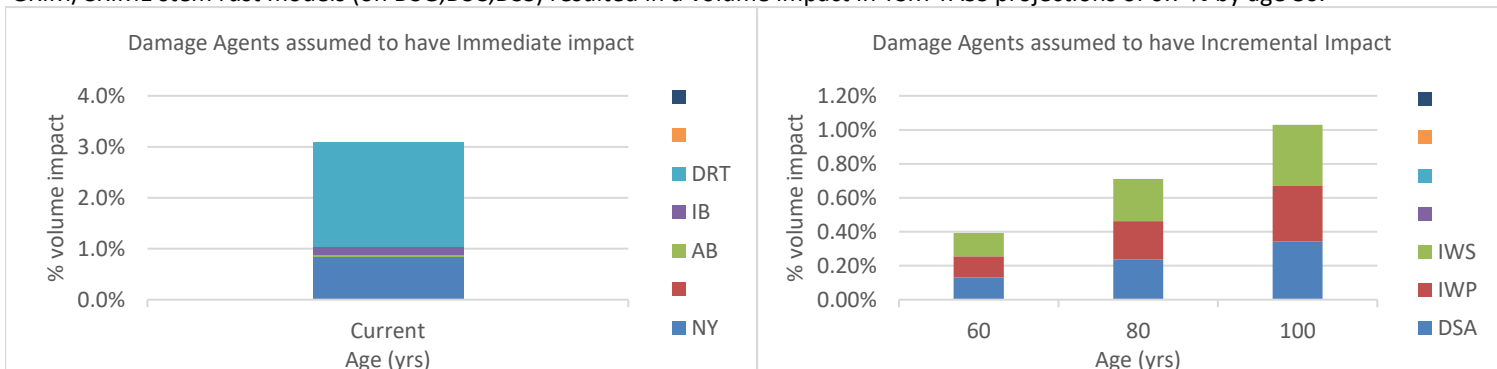
All tagged trees are assessed for up to five forest health damage agents per tree. The incidence of the 10 most frequent damage agents are summarized as a percent of the total stems by live / dead status (below). Unknown damage associated with a loss indicator is further divided into forks, crooks, or broken tops. A full list of recorded damage agent code names is on page 5.



Approximating Future Forest Health Risks

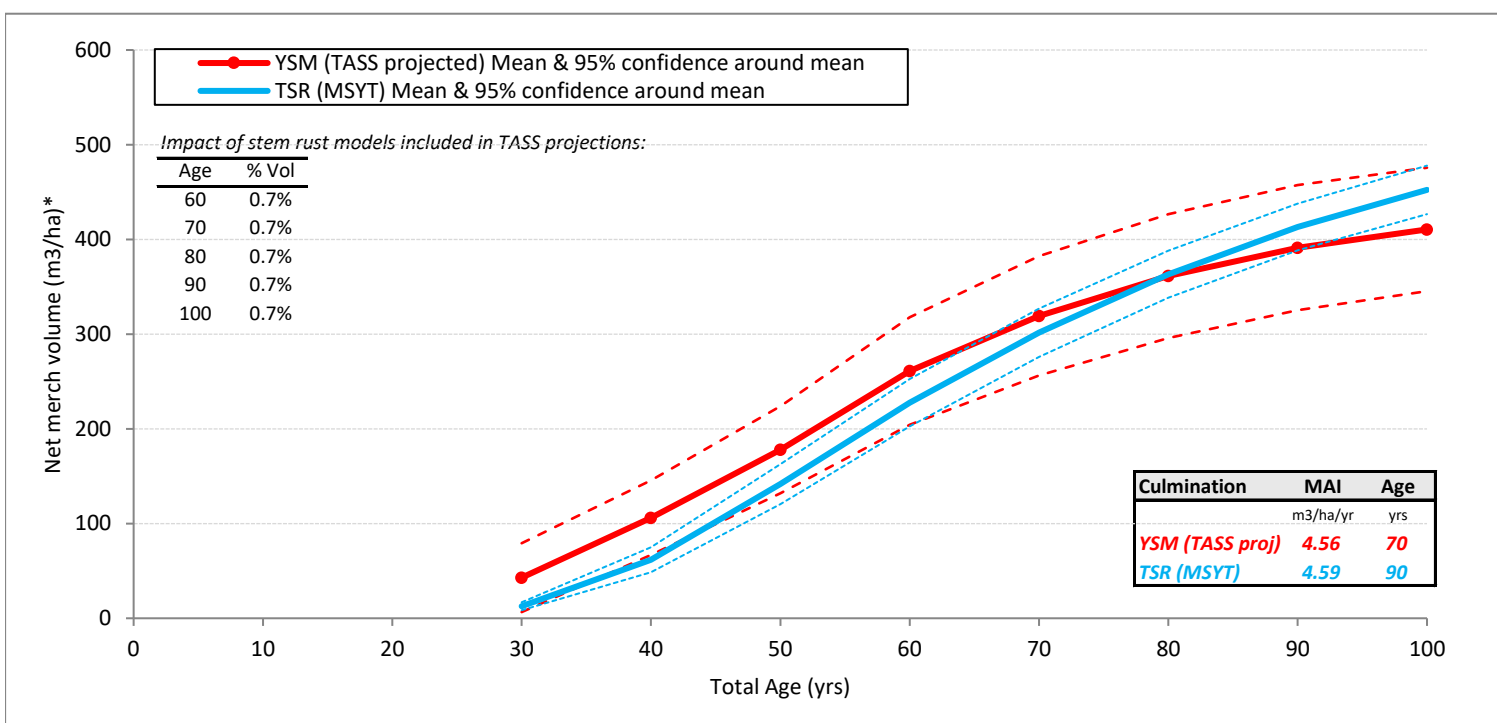
There are a number of forest health agents recorded in YSM samples that do not yet have specific forest health models built. A simplistic approach is used as an interim step to estimate future impacts, and involves creating two groups of damage agents: 1) those expected to result in immediate mortality vs. 2) those causing incremental mortality or growth loss through to rotation. For the first group, 90% of the current measured incidence is assumed to cause immediate mortality (left graph). For the second group, the impact is modeled as a product of the current measured incidence times a mortality rate of 2.5% volume loss per decade (right graph). Their combined impacts is included as an additional adjustment factor to the plotted YSM TASS projections (next section).

GRIM/CRIME stem rust models (on DSG,DSC,DSS) resulted in a volume impact in YSM TASS projections of 0.7 % by age 80.



Will Existing Young Stands Meet Expectations at Rotation?

To assess if young stands will meet future volume expectations, each YSM tree list is projected from its latest measurement date to rotation using TASS, and compared against each spatially matched TSR existing yield tables. TASS3 is run for all YSM ground samples comprising at least 80% (by basal area) of PL & SW combined, while TASS2 is run for all other YSM ground samples. No genetic gain estimates are applied, since ground based SI estimates are used for all YSM TASS projections. The average of all YSM TASS projections and their upper & lower 95% confidence interval around the mean (red lines) are compared against the average of all spatially matched TSR yield tables (blue line). If the TSR projection overlaps within the 95% confidence interval of the average YSM TASS projection, it may be reasonable to assume young stands will meet timber supply expectations. If not, there may be a need to revisit TSR assumptions. TASS YSM projections include default operational adjustment factors OAF1 (15%) and OAF2 (5%) that linearly increase to the maximum OAF1/2 at 100 years. TASS projections also incorporate the stem rust models (**GRIM** on DSG, & **CRIME** on DSC/DSS) for YSM samples measured in 2017 or later, as well as those estimated forest health impacts associated with immediate or incremental mortality (previous section). All TASS runs use the stem-mapped YSM tree data to define the spatial distribution of trees, or an assumed random pattern for those YSM samples not yet stem mapped.



* Net merchantable volume includes all species (deciduous + conifer).

Test to compare YSM TASS projections against TSR MSYTs

TSR MSYTs are evaluated against YSM TASS projections, using paired t-tests of the volume differences (TSR-YSM) when projected from 60 & 100 years. Highlighted fields (table right) indicate significant differences at alpha = 0.05. Overall percent differences are computed as (TSR-YSM/YSM), and the age at maximum absolute percent difference, is identified (table right).

Projection age (yrs)	60	70	80	90	100
% vol diff	-13%	-6%	1%	6%	10%
P-value of vol diff	0.125	0.334	0.693	0.856	0.427
# YSM samples	19	19	19	19	19

Max % vol diff	-13%
Age @max vol diff	60
Significant? (when n>=10)	No
TSR bias?	No

Total number of YSM samples by:

Sample Type			TSR Yield Table Assignment "Current to Future" Regime	YSM Plot Occupancy of trees >=4cm DBH	Availability of stem mapped YSM Samples used in TASS Projections		TASS Version used for YSM Projections			
Grid (km)		Total								
CMI	20 X 20	2	Managed_Managed	19	Treed	19	Stem mapped plots	19	TASS ver. 2	16
YSM	5 X 10	17	Total	19	Empty	0	Not stem mapped	0	TASS ver. 3	3
Total		19			Total	19	Total	19	Total	19

Tree Species and Damage Agents Recorded from YSM Samples in the Kispiox TSA

Tree Species Codes / Names		Damage Agent Codes / Names		Damage Agent Codes / Names (cont.)	
AC	Black cottonwood	AB	Bear	O	None
AT	Trembling aspen	AM	Moose	TL	Logging Wounds
BA	Amabilis fir	AS	Squirrel	TM	Other Mechanical Damage (non-logging)
BL	Subalpine fir	AX	Birds	TR	Pruning Wound
CW	Western redcedar	DDE	Rust Red Stringy Rot	U	Unknown Damage
DR	Redalder	DF	Foliage Diseases	UBT	Unknown Broken Top Damage
EP	Paper birch	DFE	Elytroderma Needle Cast	UCR	Unknown Crook Damage
FD	Douglas-fir	DFL	Pine Needle Cast	UF	Unknown Fork Damage
HW	Western hemlock	DFS	Dothistroma Needle Blight	USW	Unknown Sweep Damage
PL	Lodgepole pine	DRT	Tomentosus Root Rot	VP	Vegetation Press
SW	White spruce	DS	Stem Diseases (Cankers and Rusts)	VT	Tree Competition
		DSA	Atropellis Canker (Lodgepole pine)		
		DSC	Comandra Blister Rust		
		DSG	Western Gall Rust		
		DSS	Stalactiform Blister Rust		
		IB	Bark Beetles		
		ID	Defoliators		
		IWP	Lodgepole pine Terminal Weevil		
		IWS	White pine Weevil (on Spruce)		
		IWW	Warren's Root Collar Weevil		
		NGC	Frost Crack		
		NW	Windthrow		
		NX	Wind scarring or rubbing		
		NY	Snow or Ice (includes snow press)		
		NZ	Sunscald		

General Notes / Assumptions

- * TSR existing MSYTs are based on FAIB ver. 2020-jun-02 using TIPSy 4.4, with RESULTS opening age, species density, regen type and genetic worth, and based on spatially matched RESULTS opening ID where present, or based on aggregated RESULTS input data where Opening ID is unavailable.
- * TSR existing NSYTs were separately run using VDPY7 & the published 2019 VRI, for those YSM sample locations modeled as "existing unmanaged".
- * Each YSM GPS location is intersected with the published 2019 VRI VEGCOMP and linked to each TSR yield table by the FEATURE_ID attribute.
- * YSM samples that collectively comprise at least 80% PL & SW combined use TASS 3 (ver 3.01.21) for future yield projections. YSM samples that include all other species combinations use TASS 2 (ver. 2.07.76) for future yield projections. The rationale for using TASS3 on predominately PL/SW mixed stands is to ensure consistency when comparing YSM TASS projections against TSR MSYTs generated using TIPSy 4.4.
- * The YSM tree list and ground based attributes are projected in TASS from the ground measurement year using a reference stand age defined by the RESULTS opening ID if present, otherwise from the VRI VEGCOMP poly rank1 projected age (adjusted to year of ground sampling).
- * All YSM TASS projections include standard OAF1 (15%) and OAF2 (5%) adjustments, with OAF1 applied in a non-standard way by assigning zero OAF1 at the YSM sample's current age and volume, and linearly increasing so that 100% of the OAF1 value is achieved by age 100.
- * For those YSM samples that are stem-mapped, TASS input tree lists are generated from each sample by first clipping hexagon shaped plots from both circular 0.04ha main plot (tagged trees >9cm DBH) and 0.01ha subplot (tagged trees 4-9cm DBH), replicating each hexagon and randomly orienting and superimposing both main and subplots onto an expanded 1ha stem-mapped tree list comprising tagged trees >=4cm DBH.
- * For those YSM samples not yet stem-mapped, TASS assumes a random spatial pattern of currently measured trees.
- * TASS required input of height vigour is estimated as a ratio of current tree height divided by the plot site height of the same tree species.
- * TASS projections of YSM samples measured since 2017 include GRIM/CRIME model impacts (ie., height & %encirclement data are measured for each stem rust after this date). The impact of other recorded damage agents are approximated as having either immediate impact (@90%) or incremental impact (@2.5%/decade), and are assigned an impact group from discussions with provincial forest health specialists.
- * Potential site index estimates are from the Provincial Site Productivity Layer (PSPL) ver 7.0 intersected with each YSM GPS location.
- * YSM leading species is compared to the published VRI VEGCOMP (ver. 2019) leading species for leading species agreement, while overall species composition is compared to the RESULTS species composition used in TSR MSYTs (which includes the combined planted plus natural cohorts).
- * All histograms presented (ie., stand table, species comp, forest health incidence), are computed as pooled means of all YSM samples combined.
- * All reported net merchantable volumes are at 12.5cm close utilization for PL, 17.5cm for other species, and include all species (deciduous + conifer)
- * YSM summaries include both managed (post-harvest-regenerated) and residual cohorts. Also, the comparison between YSM and TASS PAI for remeasured YSM samples include both of these cohorts. However, comparisons of YSM TASS projections against TSR MSYTs exclude the residual cohort, to ensure consistency with assumptions made in the TSR MSYTs.

References

YSM Technical Handouts for all available TSAs, plus resource information on Provincial Monitoring Programs

<https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/ground-sample-inventories/provincial-monitoring>

Public access to Ground Sample Data approved as OpenData under BC Open Government License

<https://catalogue.data.gov.bc.ca/dataset/824e684b-4114-4a05-a490-aa56332b57f4>