

# A Comparison of the Tesera Systems High Resolution Inventory Solution for the Chinook – Fraser Lake – Stellat’en inventory area of interest: A brief overview.<sup>1</sup>

June 29, 2020

## Introduction

The purpose of this document is to provide a comparison of the HRIS forest inventory with the corresponding VRI inventory as it relates to the whole treed area. The FLNRO completed an audit of the VRI using the HRIS plots established using Systematic Random Sampling.<sup>2</sup> The VRI was found to produce reliable estimates in relation to cruise based volumes, however the HRIS volumes were found to be on the order of 60% of those estimated in the VRI.<sup>3</sup> With respect to dominant heights, stand ages, and distributions by leading species, the results were found to be reasonably reliable. These results were consistent with the subsequent self (HRIS)-audit using the same set of ground plots, highlighting the discrepancy with respect to under-estimation of HRIS volumes.<sup>4</sup>

## Further Investigation into Volume Discrepancies

The sources of the cruise versus HRIS compiled volume differences were further investigated. They were found to be the result of:

1. Using an older set of Kozak (1988) taper parameters that were consistent with those in the cruise manual, but to only 2 significant figures (This being the main source of error).
2. The use of Newton’s log compilation formula instead of the one used in the cruise compilation manual (This being a secondary and lesser source of error).

These differences particularly related to stands dominated by Spruce that contained large diameter trees (i.e. up to 65 cm dbh). Other differences were caused by compiling cruise volumes with projected heights and no correction for broken tops versus the HRIS use of height at point of being broken. A process was developed to adjust the volumes differentially for

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<sup>1</sup> Prepared on behalf of Tesera Systems Inc., by Ian S. Moss, PhD RPF.

<sup>2</sup> Mature inventory audit for management unit: Chinook cohort: Cruised based volume source (chinook\_cohort\_audit\_cruise\_volume\_based\_2020mar25.pdf).

<sup>3</sup> Mature inventory audit for management unit: Chinook cohort: HRIS-based ground volume source (chinook\_cohort\_audit\_hris\_volume\_2020mar25.pdf).

<sup>4</sup> An audit of the Tesera Systems High Resolution Inventory Solution (HRIS) developed for the Chinook and Fraser Lake Community Forests and the Stellat’en Woodland License Areas. Prepared on behalf of Tesera Systems by Ian Moss, PhD, RPF, updated and resubmitted to FLNRO, April 8, 2020 (HRIS\_Audit\_Report\_v208042020.pdf).

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different leading species (BL, DEAD, PL, and SX) as functions of the original HRIS estimates. These adjustments were applied, with the result that overall volume estimates were increased by 140%, this closely approximating the original discrepancy between the cruise compiled volumes (using CruiseComp) and those compiled using the HRIS compiler.<sup>5</sup>

## Comparison of HRIS vs. VRI: Complete Inventories

In this report, the results are reported for the VRI and for the HRIS forest inventory as a whole rather than for only those points represented by ground samples established to ensure valid statistical representation of the population of stands as a whole. The merchantable volumes have been adjusted to be consistent with cruise-based estimates as described above. To provide a little more detail, a system of stand type classification was developed using the VRI inventory, and then applied to both the VRI and the HRIS inventory as a basis for making consistent comparisons (Table 1).<sup>6</sup>

In the final analysis, the two inventories closely resemble one another at the strategic scale. (Tables 2 and 3). The following is a summary for the area as a whole:

- There is slightly more area accounted for in the VRI, partly but not wholly as a result of excluding HRIS areas derived through use of RESULTS.
- The HRIS stands are younger on average (70 versus 105 years for HRIS vs. VRI), shorter (19m vs. 21m), and with higher site indices (22 vs. 15) on an area and basal area per hectare weighted basis. This is consistent with the comparisons of the VRI and versus the ground plot data.<sup>7</sup>
- Total live tree basal area for HRIS ranges from 22 m<sup>2</sup>ha<sup>-1</sup> to 16 m<sup>2</sup>ha<sup>-1</sup> when accounting for all trees above 1.3m versus only those that are 12.5 cm dbh or larger. VRI basal area estimates fall in between with an area weighted average of 19 m<sup>2</sup>ha<sup>-1</sup>.

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<sup>5</sup> Unpublished report (CFLHrisToCruiseVolumeAdjustmentEquations\_14052020.docx). Prepared by Ian Moss, PhD RPF, May 14, 2020. Using regression involving only those ground plots with some merchantable volume, with the intercept set to zero, the cruise volume was observed to be 1.5 times the HRIS compiled volumes for the associated stand conditions. The average ratio of ground-to-stand volumes was found to be 1.4. Therefore, the figure of 140% is within the range observed in the original HRIS audit.

<sup>6</sup> Table 1. Chinook Community Forest, Fraser Lake Community Forest, & Stellat'en Vegetation Resource Inventory Classification System (CFLS\_VRI\_Classification\_0902208.pdf).

<sup>7</sup> This is consistent with comparisons of the ground plot data versus VRI and HRIS. With respect to HRIS it was found that the main source of error involved the fact that several plots were located within clumps of a few large trees within polygons that contained many more small trees, such that the differences appeared large when applying ratio adjustments, but were found to be much smaller when regressing the ground sample estimates on the polygon based estimates with the intercept forced through zero. Using regression, the slopes were found to be not significantly different from 1 within 95% confidence intervals in all three cases.

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- HRIS merchantable volumes (adjusted to cruise) are: 98, 33, and 131 m<sup>3</sup>ha<sup>-1</sup> for living, dead, and all trees greater than 12.5 cm dbh (30 cm stump and 10cm d.i.b. top), whereas VRI has a corresponding, 95, 25, and 115 m<sup>3</sup>ha<sup>-1</sup>.
- HRIS includes Willow in the live tree species component, whereas VRI does not, but willow does not contribute any merchantable volume. If willow were to be removed, the total basal area would be reduced overall by about 4%, and the corresponding remaining species percentages would be increased.
- In terms of the remaining species, the most common species is spruce with 40% of the total live tree basal area (keeping Willow in the mix) in the HRIS inventory, and 45% of the corresponding amount in VRI. The second and third most common species are pine (29 versus 21%) and then hardwoods (14 versus 22%, remembering that Willow is assigned to its own category).

## Discussion

In summary, there are differences, but the range of variation amongst the classes is reasonably consistent. Class number 1 in the HRIS inventory (Table 1) only includes data from the upper range, with very low basal areas, as a result of having excluded RESULTS data, that in turn is limited to well-spaced and/or free growing trees in addition to species composition, age, height, and site indices. It should also be pointed out that differences are expected due to the much greater resolution associated with HRIS versus VRI inventory.

The adjusted HRIS estimates of merchantable volume for live, dead, and all trees are now slightly higher than those of VRI, in contrast with the findings in the various audits, suggesting that the issue has been resolved within reasonable bounds. The HRIS inventory relies more heavily on ground sample information in its development with an emphasis on increasing the reliability of attribute estimation along with reducing the potential for bias. It is also accompanied with many more estimates for each of the attributes; this is a result of starting with attribution at a gridcell scale, in this case 20m x 20m and then summarizing these at a microstand scale. There is also the option to aggregate microstands into larger polygons if so desired.

## Conclusion

Given the HRIS process of inventory development, the evidence drawn from the various audits, the adjustments that were applied to derive more consistent estimates of merchantable volume with respect to cruise compilations and given the verifications that have been applied to ensure that such adjustments are reasonable, we believe that the inventory is suitable for both strategic and operational applications.

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Table 1. Original VRI forest type classification centroids representing Chinook-Fraser Lake-Stellat’en inventory area of interest derived using Fuzzy C-Means Classification. The classification was developed using a random sample of 15,918 VRI vegetated-treed polygons. Note that the centroids do not represent the average stand condition for each group; rather they are centroids established for the purpose of grouping stands efficiently with the complex set of variables as identified below. The variables are stand (Dominant tree) age (AGE) and height (HT), basal area per hectare (BPH), crown closure percent (CC), live and dead tree merchantable volume per hectare (MVPHL and MVPHD respectively), Aspen Group (AG; i.e. hardwoods), Douglas-fir (FDG), lodgepole pine (PLG), and spruce-balsam group (SBG) species percentages. The classification was applied to each of the HRIS and VRI inventories (Average stand conditions by class are summarized for each of HRIS and VRI in Tables 2 and 3 respectively).

CLASSNO	AGE	HT	BPH	CC	MVPHL	MVPHD	ATG	FDG	PLG	SBG
1	18	4	2	15	5	3	5	0	62	32
2	47	13	16	43	49	9	9	0	71	20
3	74	18	16	33	65	6	70	0	9	21
4	79	17	15	28	73	49	10	0	54	35
5	94	22	29	47	141	4	74	0	6	20
6	95	19	16	29	84	26	16	0	19	65
7	95	19	16	29	85	26	15	0	19	65
8	96	19	16	29	83	26	15	0	18	66
9	98	19	18	31	93	26	16	0	18	65
10	98	19	18	31	94	26	16	0	18	65
11	99	19	16	29	86	26	15	0	17	68
12	107	21	25	39	147	15	16	0	13	70
13	118	23	27	39	161	14	15	0	11	74
14	131	23	18	25	111	99	8	0	14	78
15	139	25	33	41	219	8	12	0	7	80

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Table 2. HRIS Chinook – Fraser Lake – Stellat’en inventory area of interest – HRIS TREED area without RESULTS data that would be assigned to VRI Forest Class 1. Note that BPHL represents all trees above 1.3 m in height.

VRI_FOR_CLASS	AREAHA	AGE	HT	SI	BPHL	BPHL_125	TPHL	TPHL_125	TPHD_125	TPHLD_125	CC	MVPH_L	MVPH_D	MVPH_LD	AC	AT	BL	EP	FD	LW	PL	SB	SX	W
1	11392	50	8	13	7	4	1661	169	85	254	18	16	7	23	NA	10	13	NA	0	0	47	1	26	4
2	33363	47	14	20	22	14	3477	477	125	600	56	66	15	81	NA	9	9	NA	0	0	56	1	23	3
3	2335	60	17	19	21	14	1563	454	103	557	37	51	12	62	NA	53	2	NA	0	0	6	0	13	25
4	18772	73	16	17	14	11	957	306	406	709	35	63	60	124	NA	11	14	NA	0	0	46	1	24	4
5	6413	65	22	24	34	25	2851	647	121	767	71	137	20	157	NA	46	5	NA	0	0	10	0	30	9
6	3346	83	17	16	18	13	1305	378	179	556	33	65	24	89	NA	12	17	NA	0	0	13	1	50	6
7	9	114	19	13	22	14	768	320	284	604	19	79	49	127	NA	7	47	NA	0	0	5	0	24	16
8	207	113	17	13	17	9	834	260	205	459	11	42	26	67	NA	8	40	NA	0	0	7	0	27	18
9	1112	84	19	17	21	16	1302	430	250	678	40	87	37	124	NA	13	16	NA	0	0	14	1	50	6
10	5824	85	20	18	23	17	1334	466	274	738	46	103	44	147	NA	14	14	NA	0	0	14	2	51	5
11	210	116	20	15	16	7	737	200	220	420	23	36	27	63	NA	7	43	NA	0	0	12	10	17	10
12	22171	80	22	20	31	24	2878	621	200	816	65	165	38	203	NA	10	15	NA	0	0	15	1	58	2
13	1406	108	28	21	32	25	1470	595	210	800	50	179	44	224	NA	13	17	NA	0	0	6	3	58	3
14	3544	103	26	20	17	13	544	289	614	899	46	95	127	222	NA	13	27	NA	0	0	11	2	44	3
15	5237	98	31	25	44	36	2645	790	119	902	72	297	30	327	NA	16	13	NA	0	0	4	0	64	2
<b>TOTAL</b>	<b>115342</b>	<b>70</b>	<b>19</b>	<b>20</b>	<b>22</b>	<b>16</b>	<b>2344</b>	<b>460</b>	<b>207</b>	<b>665</b>	<b>50</b>	<b>98</b>	<b>33</b>	<b>131</b>	<b>NA</b>	<b>14</b>	<b>12</b>	<b>NA</b>	<b>0</b>	<b>0</b>	<b>29</b>	<b>1</b>	<b>40</b>	<b>4</b>

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Table 3. VRI Treed Land Cover Class area summary for HRIS Chinook-Fraser Lake-Stellat’en inventory area of interest.

VRI_FOR_CLASS	AREA	A	AGE	HT	SI	BPHL	BPH_125	TPHL	TPHL_125	TPHD_125	TPHLD_125	CC	MVPHL	MVPHD	MVPHLD	AC	AT	BL	EP	FD	LW	PL	SB	SX	W
1	18356	14	3	18	NA	2	NA	2454	10	2464	14	1	1	2	0	4	4	0	1	0	59	0	32	NA	
2	15498	42	14	18	NA	18	NA	1759	33	1791	51	45	1	46	0	4	3	0	0	0	77	0	15	NA	
3	8153	72	18	16	NA	14	NA	684	35	719	30	51	3	54	3	74	0	1	0	0	5	0	16	NA	
4	8736	85	19	15	NA	15	NA	466	424	891	23	78	75	154	0	3	2	0	0	0	75	0	19	NA	
5	8468	94	22	17	NA	32	NA	798	24	822	50	155	0	155	4	76	0	1	0	0	3	0	16	NA	
6	1475	61	15	17	NA	15	NA	1115	111	1226	36	54	15	69	1	12	6	0	1	0	22	3	55	NA	
7	47	104	20	12	NA	16	NA	265	172	437	27	83	54	138	0	24	0	2	0	0	16	0	58	NA	
8	4792	74	16	15	NA	9	NA	551	123	673	21	35	15	50	2	10	7	0	0	0	11	11	60	NA	
9	235	72	19	18	NA	18	NA	717	160	877	35	90	17	107	0	16	6	0	1	0	24	2	50	NA	
10	2019	81	19	16	NA	20	NA	760	112	873	38	98	13	111	1	12	6	0	1	0	18	3	59	NA	
11	5201	128	21	12	NA	12	NA	413	86	499	21	65	9	75	1	4	17	0	0	0	4	9	64	NA	
12	7334	79	19	17	NA	28	NA	1135	71	1206	48	137	4	141	0	11	12	1	0	0	15	1	59	NA	
13	5094	136	23	12	NA	25	NA	613	93	706	35	152	6	159	1	8	21	0	0	0	6	1	63	NA	
14	12474	141	25	13	NA	18	NA	375	411	786	23	112	136	248	0	5	13	0	0	0	12	1	69	NA	
15	14997	152	26	13	NA	36	NA	670	97	767	44	240	8	247	1	9	20	0	0	0	5	1	63	NA	
TOTAL	112877	105	21	15	NA	19	NA	1090	123	1213	33	95	25	119	1	20	10	1	0	0	21	1	45	NA	