HRL 2018 look & feel verification report for Dominant leaf type change 2015 - 2018

I. Administrative part

HRL	*Dominant leaf type change*
Verified area, region	*Finland*
Institution carrying out the work	Natural Resources Institute Finland
Overall visual checking done by (name, position and e-mail)	Hanna Huitu, researcher, hanna.huitu@luke.fi Matti Katila, researcher, matti.katila@luke.fi
Look & feel verification done by (name, position and e-mail)	Hanna Huitu, researcher, hanna.huitu@luke.fi
Statistical verification done by	Matti Katila, Researcher, matti.katila@luke.fi
In situ data used	*National Forest Inventory field plot measurements (NFI)/ Luke from systematic cluster sampling with NFI permanent field plot pairs 2012-2014 and 2017-2019 except for Ahvenanmaa sampling region 2013 and 2018, and excluding Ylä-Lappi (Northern Lapland) (see Fig. 2. for sampling regions). Data set covers all landuse classes except sea water, n=7777.*
	Multi-Source National Forest Inventory)/Luke *Resolution: 16 m* *Reference years:2015, 2017, 2019*
	National Ortho photo database/The National Land Survey *Natural color/black and white ortho images* *False-color (CIR) images* *Resolution: 0.25-0.5m* *Reference years: 2014-2020 (partial coverages)*
	Polygon database of forest stands)/ Finnish Forest Center *Reference year 2021(partial coverage)*
	Topographic database of National Land Survey
	In-house data set for cut forest areas (2012-2017, Natural Resources Institute Finland)
	In-house data for crown cover based on Lidar data (Finnish Environment institute, partial coverage)
Reporting done by (name, position and e-mail)	Hanna Huitu, researcher, hanna.huitu@luke.fi Matti Katila, researcher, matti.katila@luke.fi
Date and place of writing the report	Helsinki 28.6.2021

II. General overview of the verified data

General overview of the verified data	*Statistical information chart about the verified data.*

General information

High resolution Layer for Dominant Leaf Cover Change (2015-2018) is a classified raster layer, a change product that presents various possible leaf type changed between two reference years in 20 m spatial resolution. Main aim of this verification exercise is identification of false changes. Verification is targeted to following classes: New broadleaved cover, New coniferous cover, Loss of broadleaved cover, Loss of coniferous cover, and Potential change among dominant leaf types.

Statistical information charts, overview image and comparison to national statistics

Total area covered by values in HRL Dominant Leaf Type Change layer is 347 185 km^2. Out of this total area, unchanged areas cover 98.9 % (area with tree cover 62.4 % and area with no tree cover 36.5 %). New tree cover totals 4.8 km^{2}in total, and loss of tree cover 3 783.7 km^2 in total. Shares of area are shown in Table 1.

Table 1. Overview statistics

HRL DLTC18 Finland	Value	Km2	%
0	Unchanged areas with no tree cover	126 706.7	36.5
1	**New broadleaved cover**	**2.5**	**0.0**
2	**New coniferous cover**	**2.3**	**0.0**
3	**Loss of broadleaved cover**	**648.3**	**0.2**
4	**Loss of coniferous cover**	**3 135.4**	**0.9**
10	Unchanged areas with tree cover	216 668.7	62.4
12	**Potential change among dominant leaf types**	**20.7**	**0.0**
254	Unclassifiable in any of the parent status layers		
255	Outside area (no data)	428 749.4	

Overview image (Fig.1) shows division of values in HRL Dominant Leaf Type change 2015 - 2018 layer within Finland. Areas where changes are identified are small and scattered within the country.

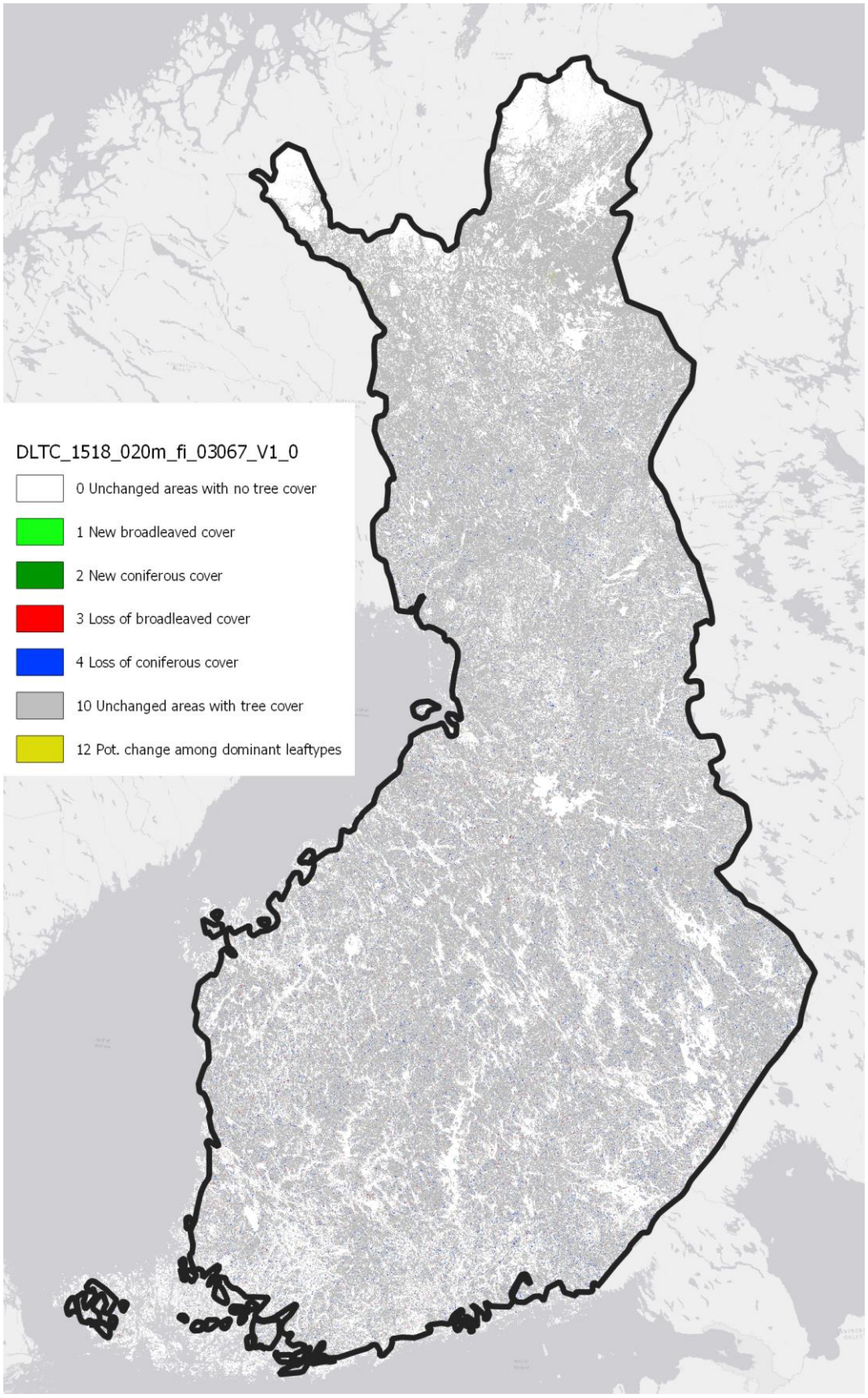

Fig. 1: Overview image, HRL DLTC 2015-2018

HRL Dominant Leaf Type Change layer was compared to national statistics (see Table 2.). Based on this comparison, the change layer HRL DLTC 2018 may contain a somewhat reasonable area for loss of forest cover, and a clear underestimate of new forest cover areas. For changes between dominant leaf types, comparable statistics on changes were not available.
During 2015-2017 period, regeneration fellings totalled to 4 991 km^2 (comparable to total 3 784 km^2 in HRL DLTC classes for losses of tree cover). As one indication of new forest cover emerging in the area to balance this out, area of total forest cover has remained stable for last decades and other land uses have not taken over.

Table 2. Statistics on forest fellings and development of forest area in Finland

	Regeneration fellings (as sum of clear cutting, seed tree fellings, shelterwood fellings and other regeneration fellings)	**Forest area** (as a sum of Forest land and Poorly productive forest land by national definition)	Source for forest area information
Year	km2	km2	
2007	2 043	228 200	NFI10(2004-2008)
2008	1 295		
2009	1 048	227 660	NFI11(2009-2013)
2010	1 652		
2011	1 237		
2012	1 375		
2013	1 634		
2014	1 749	228 120	NFI12(2014-2018)
2015	1 539		
2016	1 687		
2017	1 765	227 870	NFI12/13(2015-2019)
2018	2 048		

Source: For regeneration fellings, Official Statistics Finland: Natural Resources Institute Finland; Finnish forest centre1;
For forest area, "Land classes on forestry land (1000 ha) by inventory, region and land class. Natural Resources Institute Finland.

Summary of experiences about data quality

- Positional errors were not encountered in the visual scanning of the HRL DLTC 2015-2018 layer over orthophotos, topographic vector database and MS-NFI thematic layers
- Out of the 66 NFI reference field plots where changes (classes 1-4,12) were detected by HRL DLTC change layer, 47 field plots were unchanged according to permanent NFI field plots. However, one percentage tree cover threshold is very low for NFI plots to detect loss of tree cover (see part VI Statistical verification for full statistics).
- National statistics (table 2.) suggests omissions in change classes New broadleaved and New coniferous forest cover in the HRL layer.
- Strong spatial clustering of change 2. “New coniferous cover” observations onto one location (Fig.2) and lack of this class elsewhere in Finland is not correct.
- Delineation of many changed areas was found insufficient in Look and Feel verification (Fig. 4. and 5.)

III. Overall visual checking

Positional accuracy			
Relative positional accuracy	Quick visual comparison of HRL data with available EO imagery (identifying large positional errors)	*OK*	Large positional errors were not detected in the data.
Thematic accuracy			
Classification correctness	Simple look & feel thematic check (identifying basic thematic mistakes)	*OK*	*Quick visual comparison of the DLTC1518 over MS-NFI thematic layers and national orthophoto registry shows fair agreement. The identified losses of tree cover seem correctly identified. Change of dominant leaf type has been detected on areas treated with silvicultural operations such as thinning. These operations in general may change the dominant leaf type, however no evidence of leaf type changes was found on national data.* *New tree cover has been detected on relevant locations that have undergone cuttings earlier. However, due to low area captured by the detected changes, omissions are suspected among new tree cover.*

IV. Look & feel verification results

Details of look & feel verification

1.Verified change classes

Stratum	Name of the stratum (see proposed strata in Tables 5.2.2.x.b)	Number of samples verified	*Results of the verification by strata (excellent, good, acceptable, insufficient, very poor): see chapter 5.2 of the guidelines*
1	DLT class 1: New broadleaved cover	56	**Acceptable** (3) Problems with classification were caused by misclassification of status on 2015 (crown cover of 2015 was not detected) when compared to national data, or poor delineation of the stands.
2	DLT class 2: New coniferous cover	56	**Insufficient** (2) Problems with classification were caused by misclassification of status on 2015 (crown cover of 2015 was not detected), or poor delineation of the stands.
3	DLT class 1: Loss of broadleaved cover	108	**Acceptable** (3)
4	DLT class 2: Loss of coniferous cover	150	**Good** (4)
12	DLT class 12: Potential change among dominant leaf types	150	**Insufficient** (2). Proposed change polygons were seldom supported by information found on national data (2014-2020). However, management operations on mixed forests do alter leaf type dominance but this is challenging to verify.
N		520	
Overall evaluation			**Acceptable** (3)
Comments, overview of results			Number of contiguous polygons larger than minimum mapping unit was below 100 for classes New broadleaved cover and New coniferous cover.

V. Documentation of errors and critical findings

Please include detailed descriptions, meaningful examples and screenshots of errors, critical findings. Please make sure the nature, location and frequency of the issue is described in some detail. Screenshots should contain ETRS1989 LAEA coordinates.

Validating each change polygon included checking its status both in 2015 and 2018, and then assessing whether delineation of the changed area is correct.

Large part of **New coniferous cover** (41 change polygons in total) were detected in one cluster in Ostrobotnia region (see Figure 2.). These stands were pine-dominated and growing on dry soil. Concentration of this class in one region and scarcity of the class elsewhere is not correct.

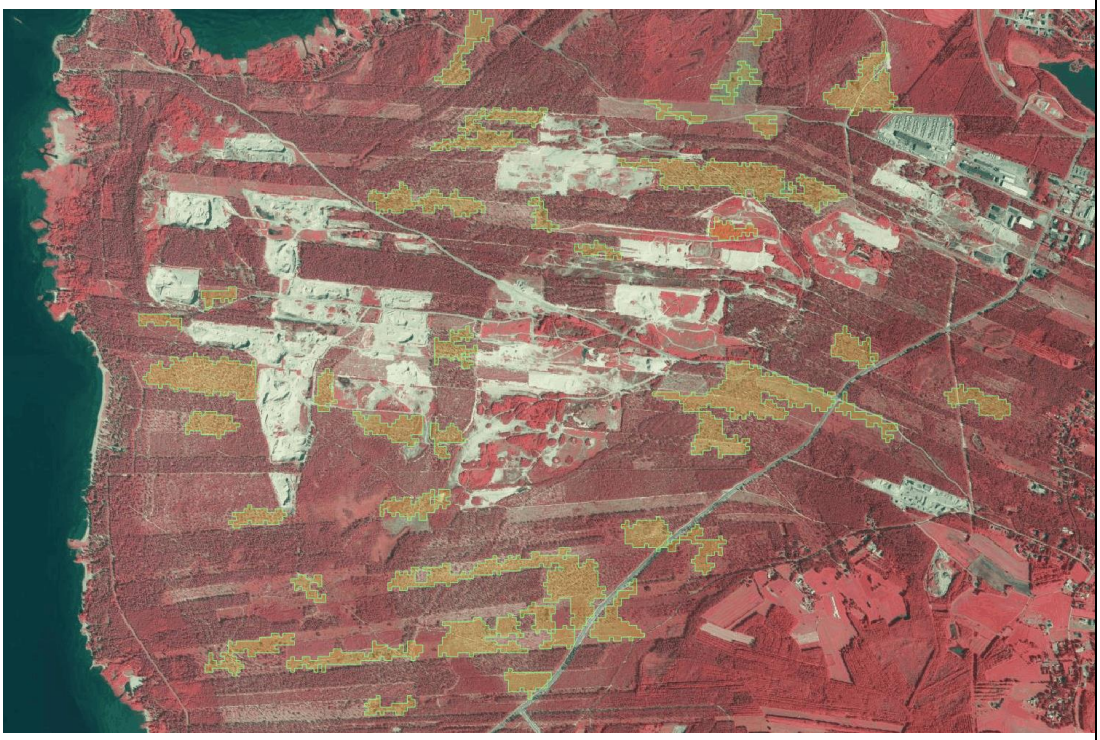

Fig. 2. Erroneous classification of large group of polygons as "New coniferous cover". Some of the selected stands have coverage of seed trees in 2018. Open (white) areas are mostly sand and gravel pits.

For **Loss of broadleaved/coniferous tree cover** – change types, both detection and delineation were often successful. Some cases were identified where only part of the trees in the stand were felled but individual seed- or shelter trees were left on the area. As the status of 2018 then has > 1 % crown cover, this may technically represent a decrease in tree cover, not loss.

For change types for **New broadleaved/coniferous tree cover**, the two common errors were timing and delineation. Often crown cover had already been detected in 2015 (and thus the change should have happened already before 2015). An example of this is presented in Figure 3, showing the status in 2015.

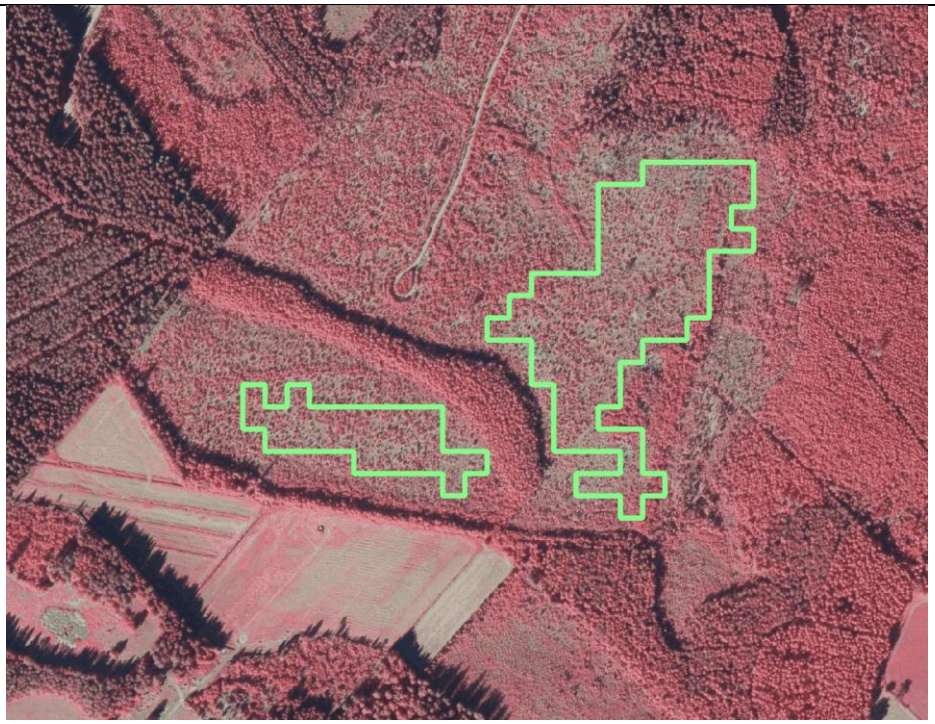

Fig 3. Old change detected as new. Change polygon classified as New broadleaved, with 2015 CIR imagery on the background already indicating crown cover > 0. Existence of crown cover in 2015 was also verified by national data from MS-NFI 2015.

Change polygons for new coniferous/broadleaved tree cover were often delineated too small, leaving edges of the same stand out. Examples of this delineation problem are given in Figures 4 and 5.

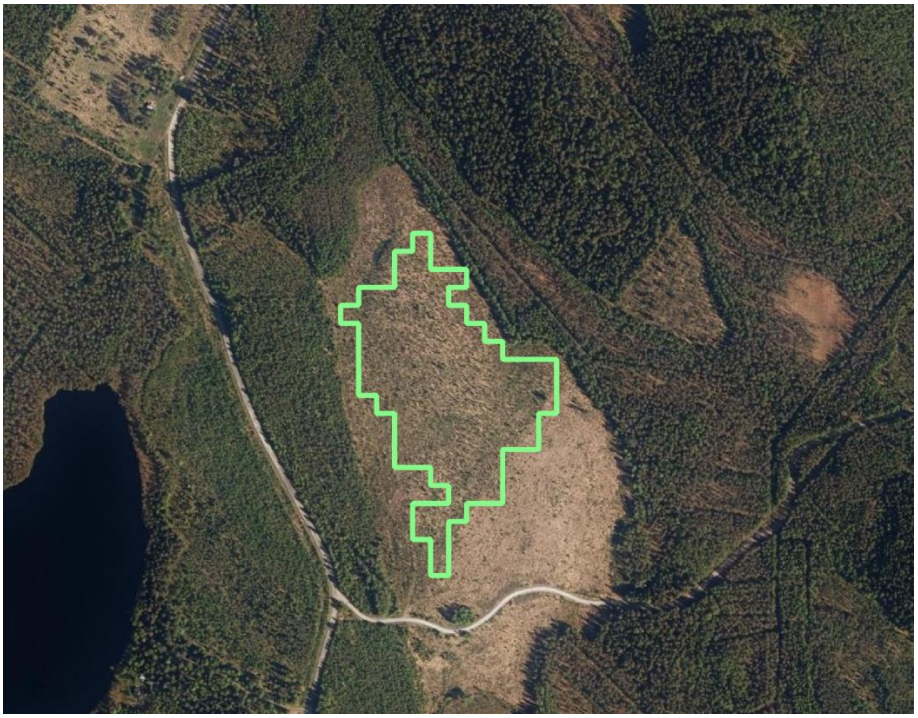

Fig. 4 Polygon for "New broadleaved" class on top of aerial imagery. Delineation of polygon is small and leaves out borders of the forest stand.

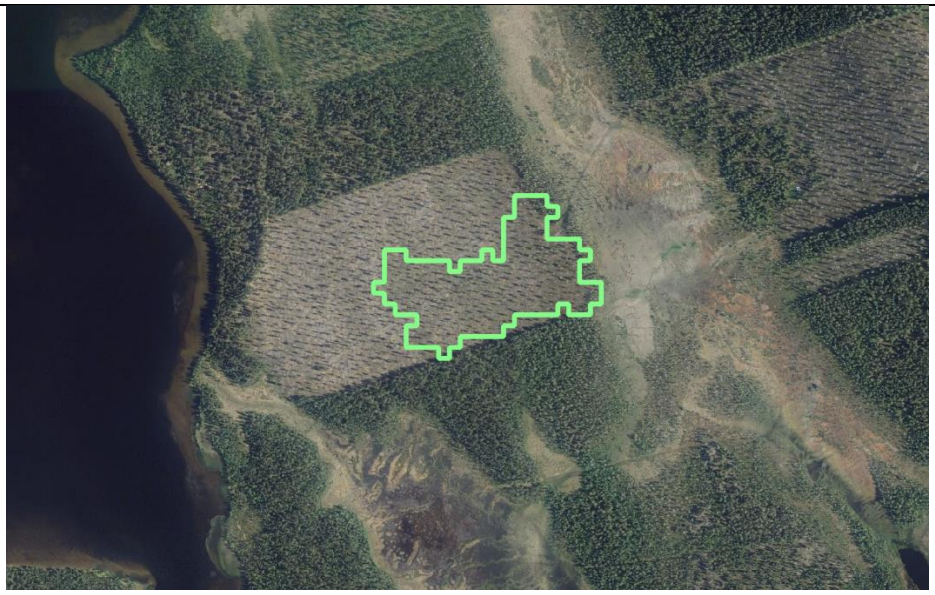

Fig. 5- Polygon for Potential leaf type change, laid over pine-dominated forest stand that has been cut, with individual pines left as seed trees. Here change of dominant leaf type was not observed in national data and is difficult to verify. Delineation covers only part of the changed area

VI. **Statistical verification** (optional)

Description of methodology and software	For statistical verification of the HRL forest layers, there is an extensive field sample available based on systematic cluster sampling. The field sample was NFI permanent field plot pairs 2012-2014 and 2017-2019 except for Ahvenanmaa sampling region 2013 and 2018, and excluding Ylä-Lappi (Northern Lapland). For the plots on the national forest land the crown cover (cc) was available. The data set contained 7777 pairs of permanent field plots, which are re-measured every fifth year, on all land use classes except sea water. In addition for the plots selected the minimum distance to the nearest stand boundary was 20 m on national forestry land and 12.5 or 9 m on non-forestry land, depending on the NFI cycle. For the national land use definitions, see Tomppo, E., Heikkinen, J., Henttonen, H.M., Ihalainen, A., Katila, M., Mäkelä, H.,Tuomainen, T. & Vainikainen, N. 2011. Designing and conducting a forest inventory - case: 9th National Forest Inventory of Finland. Springer, Managing Forest Eco-systems. The canopy cover percentage was readily modeled for the field plots on the forest, poorly productive forest land and unproductive land (national land classes) plots (Mäkisara K., Katila M., Peräsaari J. (2019). The multi-source national forest inventory of Finland – methods and results 2015. Natural resources and bioeconomy studies 8/2019. Natural Resources Institute Finland (Luke). http://urn.fi/URN:ISBN:978-952-326-711-4, sect. 3.2.1).). For more details about estimating the canopy cover for the NFI field plots see the Tree Cover Density verification report section V. The broadleaved-coniferous dominance was derived from the proportion between cc of broadleaved trees and total cc.
Stratification	No stratification was used, see below.
Comments	Field measurements from the national forest inventory (NFI) were used as ground truth data in this verification. NFI is based on systematic cluster sampling over all land use classes and ownership types. Number of field plots per area decreases towards north. The country is divided into six inventory areas. In Finland, over 78 % of the land area is covered by forestry land. Due to sampling methodology, no stratification was used. Note that a subset of field plots within forest stands was selected for validation set; selected the minimum distance to the nearest stand boundary was 20 m and 12.5 or 9 m on non-forestry land, depending on the NFI cycle. According to suggestion in the Guidelines we chose to validate only the plots labelled for DLTC classes: 1-4 and 12 from the product (see Table 1). Because only DLTC classes 3 and 4 (Loss of broadleaved cover and

	loss of coniferous cover) had significant area cover there were NFI permanent plots detected on those DLTC classes. Consequently, the number of observations was small n=66 plots. The threshold of 1 % of canopy cover is very low for NFI plots to classify a loss of tree cover. This and the small amount of plots makes comparison difficult.

Table 3 Classification error matrix for dominant leaf type change 2015-2018 using remeasured permanent NFI field sample plot pairs 2012-2014 and 2017-2019 (Ahvenanmaa 2013 and 2018). All land use classes except sea water. A subset of NFI plots with DLTC label 1-4 and 12 was chosen.

Confusion Matrix

		Reference Data							
		Unchanged areas with no tree cover	New coniferous cover	Loss of Broadleaved cover	Loss of coniferous cover	Unchanged areas with tree cover	Potential change among dom. leaf	UserAccuracy	UserAccuracyVariance
Classification Data	Unchanged areas with no tree cover	0	0	0	0	0	0	0,00 %	0
	New coniferous cover	0	0	0	0	0	0	0,00 %	0
	Loss of Broadleaved cover	3	0	1	0	4	2	10,00 %	0,196
	Loss of coniferous cover	2	1	0	2	38	13	3,57 %	0,049045
	Unchanged areas with tree cover	0	0	0	0	0	0	0,00 %	0
	Potential change among dom. leaf types	0	0	0	0	0	0	0,00 %	0
	Weights	0	0	10	56	0	0		
	ProducerAccuracy	0,00 %	0,00 %	100,00 %	100,00 %	0,00 %	0,00 %		
	ProducerAccuracyVariance	0	0	0	0	0	0		
	PortmanteauAccuracy	92,42 %	98,48 %	86,36 %	18,18 %	36,36 %	77,27 %		
	PortmanteauAccuracyPartial	0,00 %	0,00 %	10,00 %	3,57 %	0,00 %	0,00 %		

OverallAccuracy	**0,045455**
OverallAccuracyVariance	**0,051124**
AllocationDisagreement	**0**
Shift	**0**
Exchange	**0**
QuantityDisagreement	**0,954545**
AMI	**0,122581**
AMIAdjusted	**-0,03063**

AMIVariance	0,14233
Kappa	0,01795
KappaVariance	0,307398