



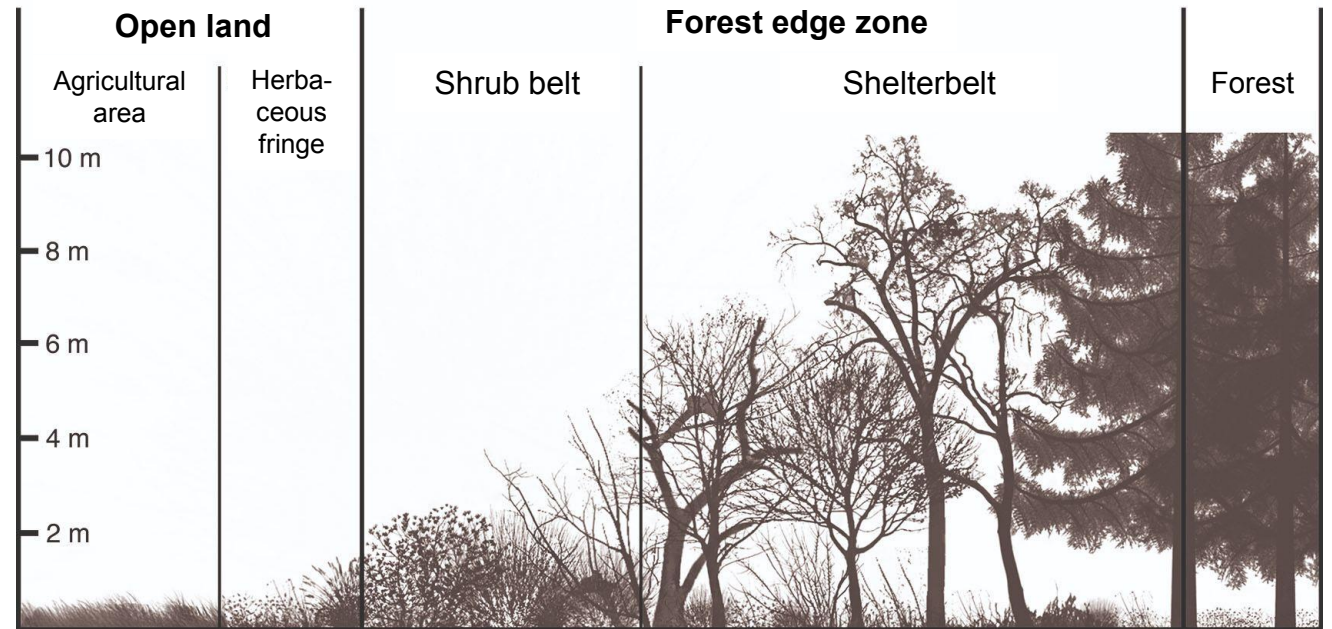
A research institute
of the ETH Domain

Countrywide characterization of forest edge structure from airborne laser scanning data

Moritz Bruggisser, Zuyuan Wang, Christian Ginzler, Lars T. Waser

Remote Sensing Lectures, 10.5.2023

Forest Edges



Wang et al. (2020)



Forest Edges – NFI

Ecological assessment

Ecotone value

$$\text{Ecotone Value} = \text{WRARTEN} + 2 \cdot \text{WRSTRUKT}$$



Ecotone quality classes

- 3 classes (low, medium, high quality)

WRARTEN

Artenvielfalt am Waldrand.

Die Artenvielfalt am Waldrand WRARTEN wird aus den drei Kriterien WRDORN (Anteil Dornensträucher), WRWEICH (Anteil Weichhölzer, Pioniere, Spezialisten) und WRANZART (Anzahl Gehölzarten total) hergeleitet.

Die metrische Variable erreicht theoretisch Werte zwischen 1 und ca. 200. Dieses theoretische Maximum bedingt das Vorkommen aller Arten gleichzeitig sowie eine optimale Verteilung, was in der Natur nicht anzutreffen ist. Praktisches Maximum im Testgebiet 1995 = 45 (Mittelwert = 21).

$\text{WRARTEN} = \text{WRDORN} + \text{WRWEICH} + \text{WRANZART}$

Wertebereich: 1 - 57

Variablendokumentation LFI1:

Verfügbarkeit: Bedingt erhältlich

Herkunft: Abgeleitetes Merkmal

letzte Aktualisierung: 27.1.2000/JZ

WRSTRUKT

Strukturvielfalt des Waldrandes, hergeleitet aus der terrestrischen Waldrandaufnahme.

Die Strukturvielfalt WRSTRUKT basiert auf den 6 Kriterien Waldrandaufbau, Waldmantelbreite, Strauchgürtelbreite, Krautsaumbreite, Waldrand-Verlauf und Waldranddicke.

Die metrische Variable erreicht Werte von 6 bis 30.

$\text{WRSTRUKT} = \text{AUFBAU} + \text{MANTELBR} + \text{STRABR} + \text{KRAUTBR} + \text{VERLAUF} + \text{DICHT}$

Die Codes müssen zur Herleitung von WRSTRUKT wie folgt gewichtet, resp. umgesetzt werden.

Merkmal	Gewichtung
AUFBAU:	1=1; 2=2; 3=2; 4=2; 5=3; 6=4; 7=5
MANTELBR:	0*-2m=1; 3+4m=2; 5+6m=3; 7+8m=4; >8m=5
STRABR:	0*+1m=1; 2m=2; 3m=3; 4+5m=4; >5m=5
KRAUTBR:	1=1; 2=2; 3=3; 4=5; 5=7
VERLAUF:	Codes bleiben
DICHTE:	1=1; 2=2; 3=3; 4=3

*: Missing Value werden wie 0 betrachtet und auf 1 gesetzt, falls Waldrandbeschreibung vorhanden.

Wertebereich: 7 - 28

Variablendokumentation LFI1:

Verfügbarkeit: Bedingt erhältlich

Herkunft: Abgeleitetes Merkmal

letzte Aktualisierung: 28.1.2000/JZ

Forest Edges – NFI vs. ALS

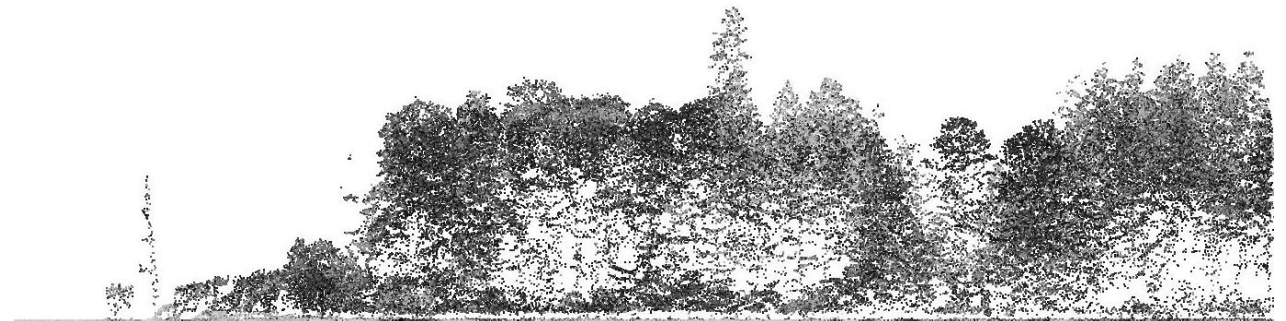
NFI

- Strong focus on 2D characteristics

Merkmal	Gewichtung
AUFBAU:	1=1; 2=2; 3=2; 4=2; 5=3; 6=4; 7=5
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ALS

- 2D information from ALS difficult to compare to field-measured metrics
- Species information is missing



Forest Edges from ALS

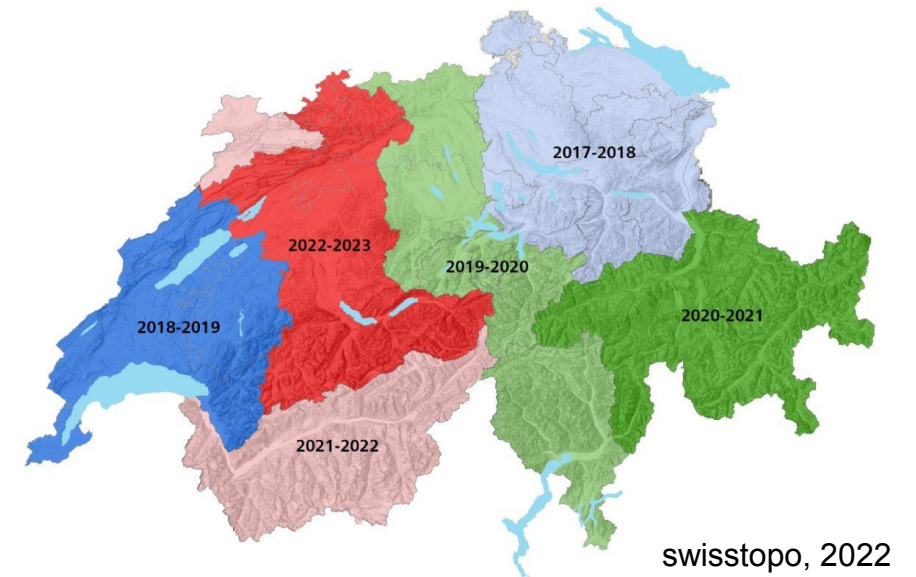
ALS forest edge product

Product specifications

- Countrywide, quasi-continuous product
 - Federal Office of Topography swisstopo
 - Data from cantonal administrations
- 3D structure including understory

Usage

- Monitoring
 - Repetitive flight missions in the future
 - Continuity of data stream



Forest Edge Plots

Basic entity

Edge zone

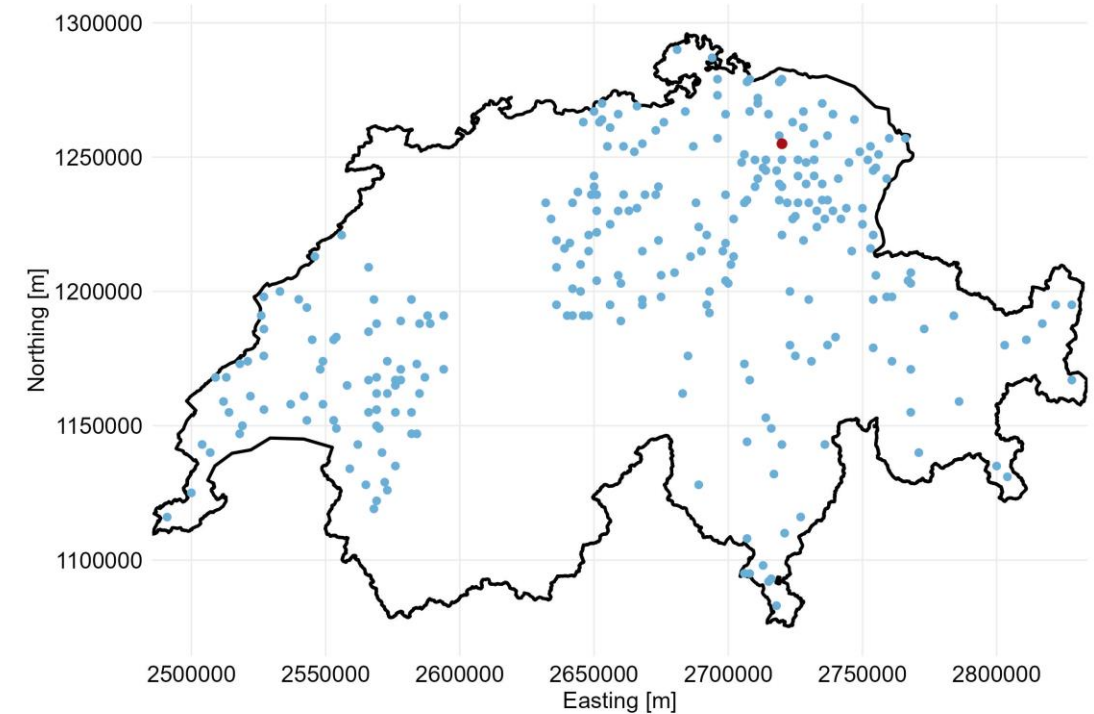
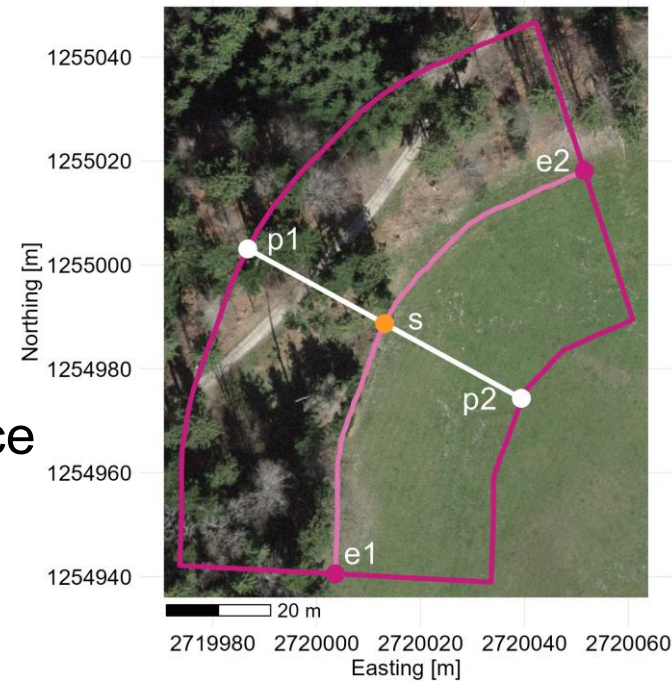
- Length: 100 m
- Width: 60 m

Plot selection

- Sampling scheme
- NFI plots as reference

Auxiliary layers

- Forest mask
- Land use information



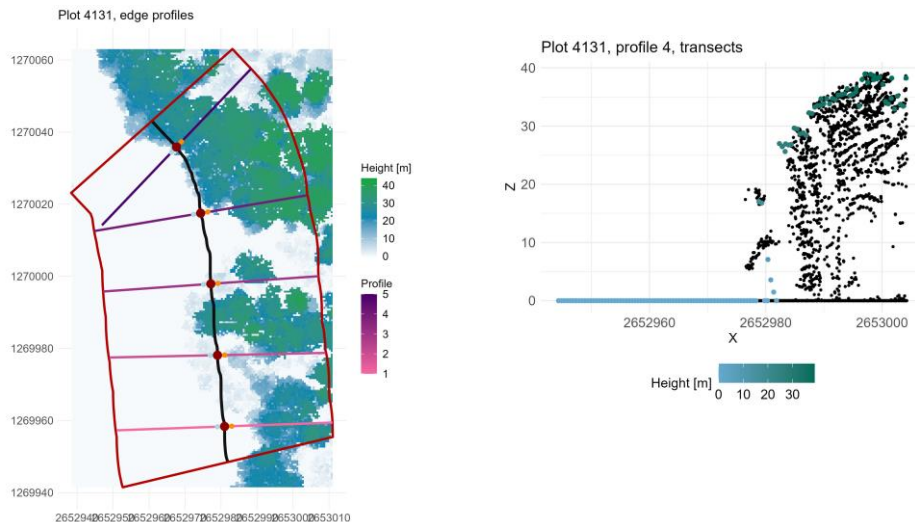
ALS Metrics

Plot metrics

- Calculated from the CHM for the entire plot

Profile metrics

- Calculated for profiles perpendicular to the forest boundary line



Metrics	Description
Plot metrics	
Height variability	Coefficient of variation of canopy height (CHM)
Forest edge composition	Area proportions of edge components: - Shrub layer: 0.5 – 4 m - Intermediate layer: 4 – 16 m - Forest layer: > 16 m
Sky-view factor	
Profile metrics	
Shelterbelt slope	max. height increase in 1 m ground distance max. slope angle in 1 m ground distance slope angle to h50, h75, h95
Horizontal visibility	Visibility into the forest

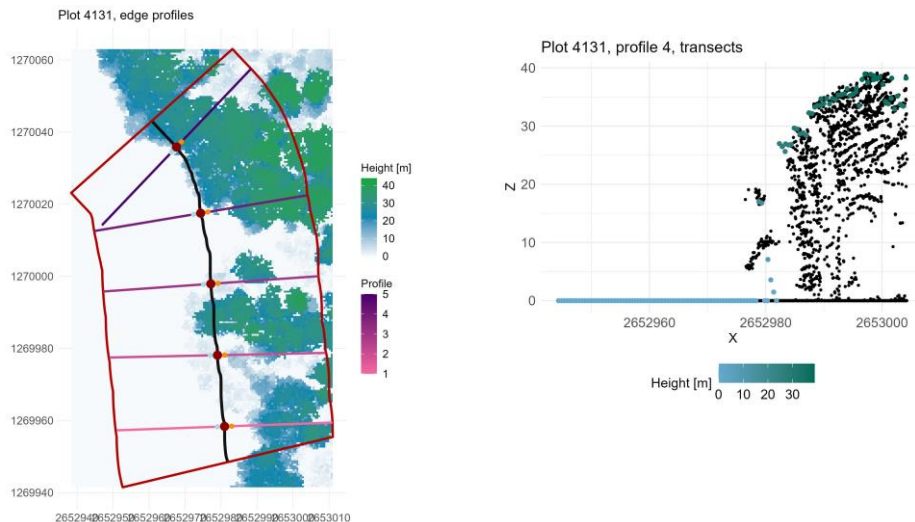
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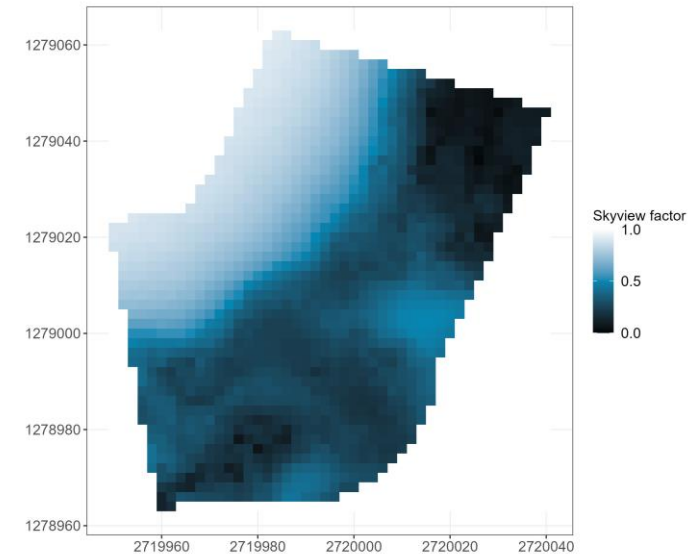
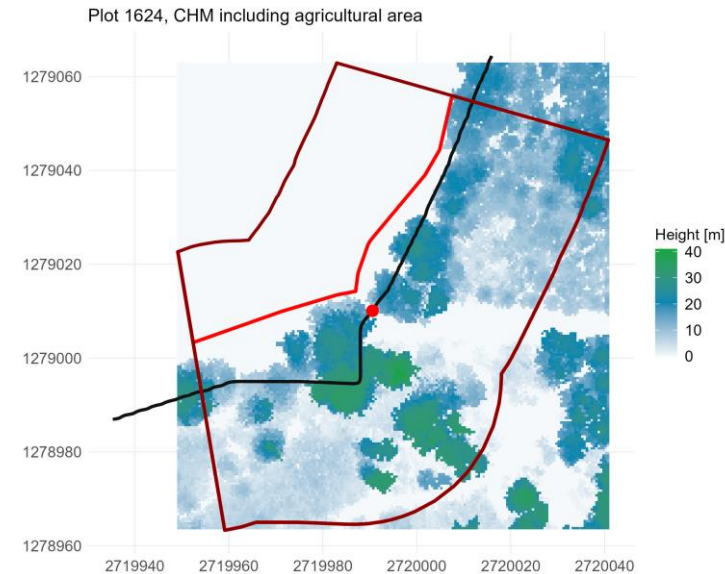


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ALS Metrics

Sky-view factor

- CHM-based calculation of canopy transmittance
- 2 m raster grid
- Virtual camera 1.5 m above ground

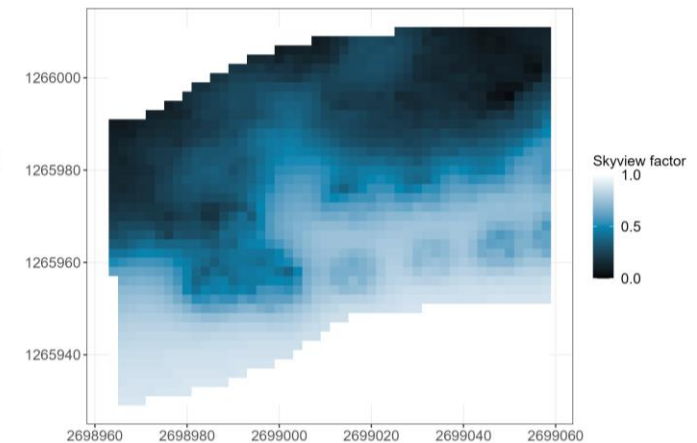
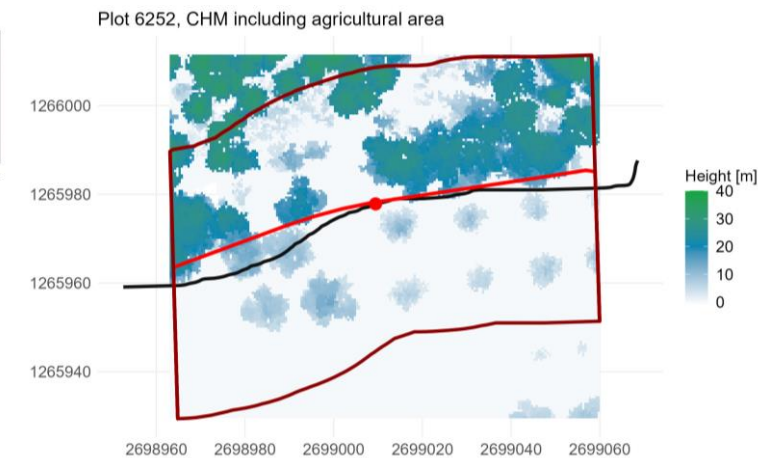


Remote Sensing of Environment 249 (2020) 112017



Enhancing airborne LiDAR data for improved forest structure representation in shortwave transmission models

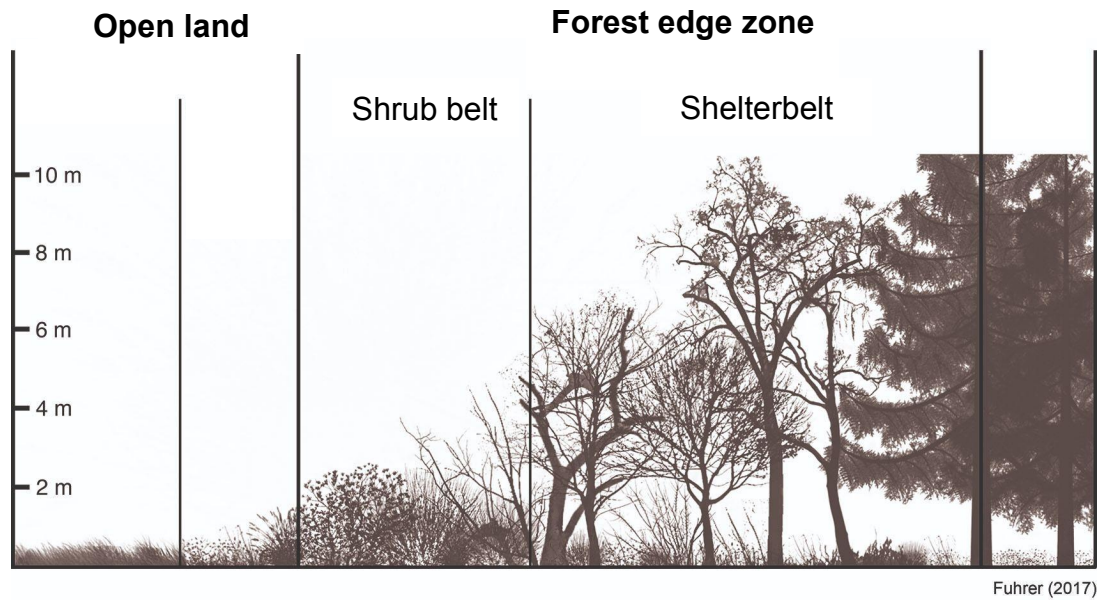
Clare Webster^{a,b,c,e}, Giulia Mazzotti^{a,d}, Richard Essery^c, Tobias Jonas^a



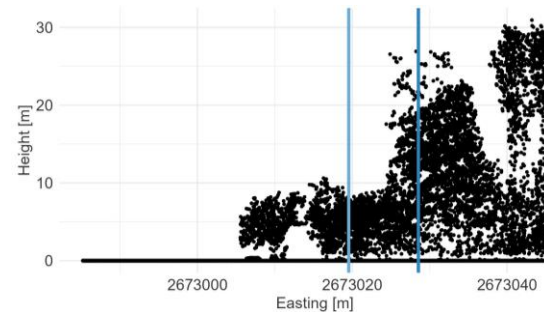
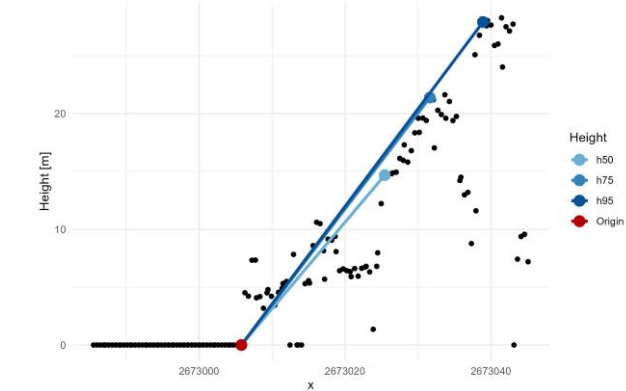
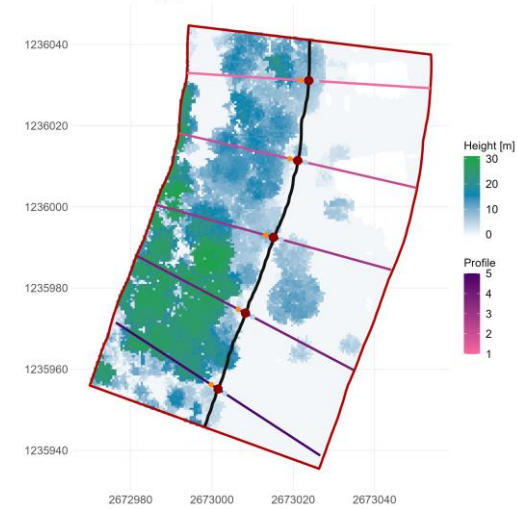
ALS Metrics

Shelterbelt slope

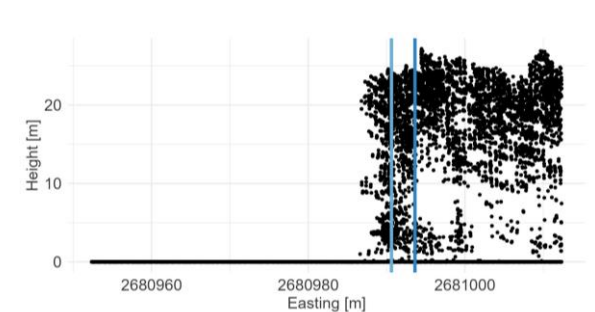
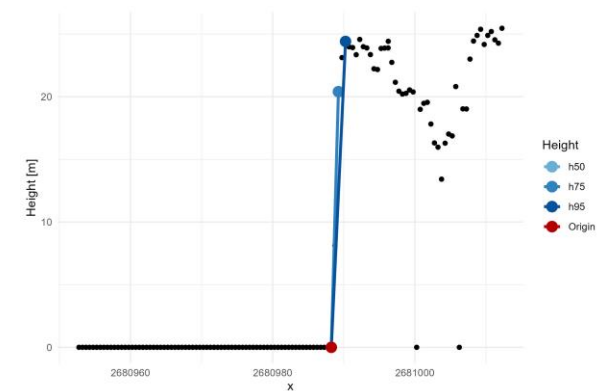
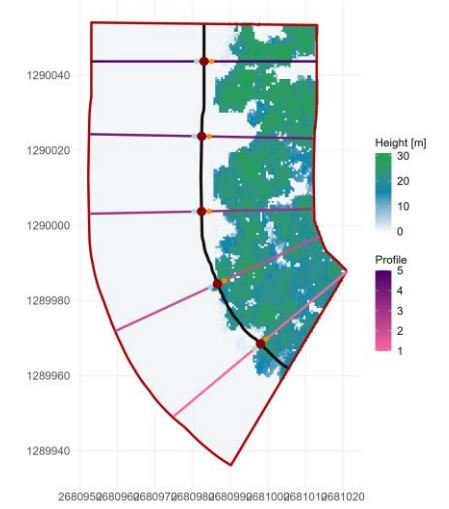
- *max. delta H and max. slope angle* between neighboring cells
- Slope to height levels (*h50*, *h75*, *h95*)



Plot 28640, edge profiles



Plot 203, edge profiles



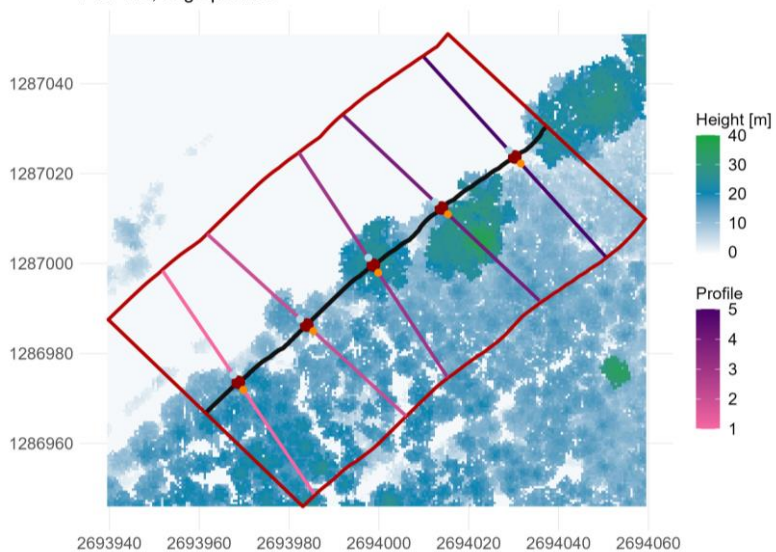
ALS Metrics

Horizontal visibility

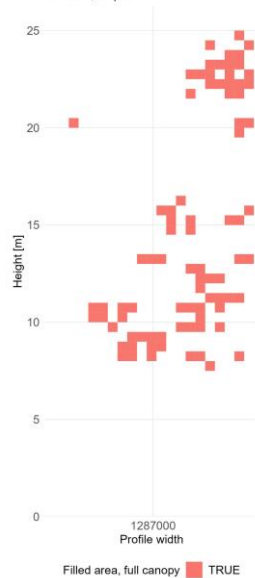
Canopy density in horizontal direction

- Basis: 0.5 m voxels
- Fraction of filled area to depth x from front

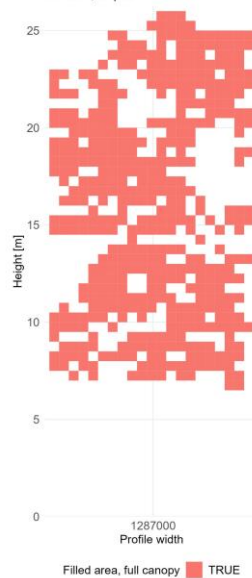
Plot 476, edge profiles



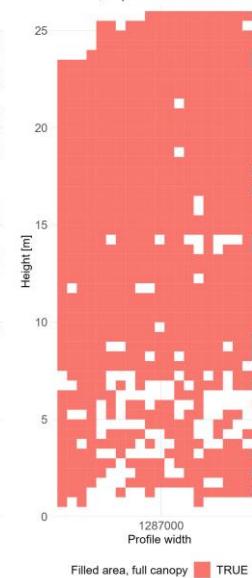
Plot476, depth = 1



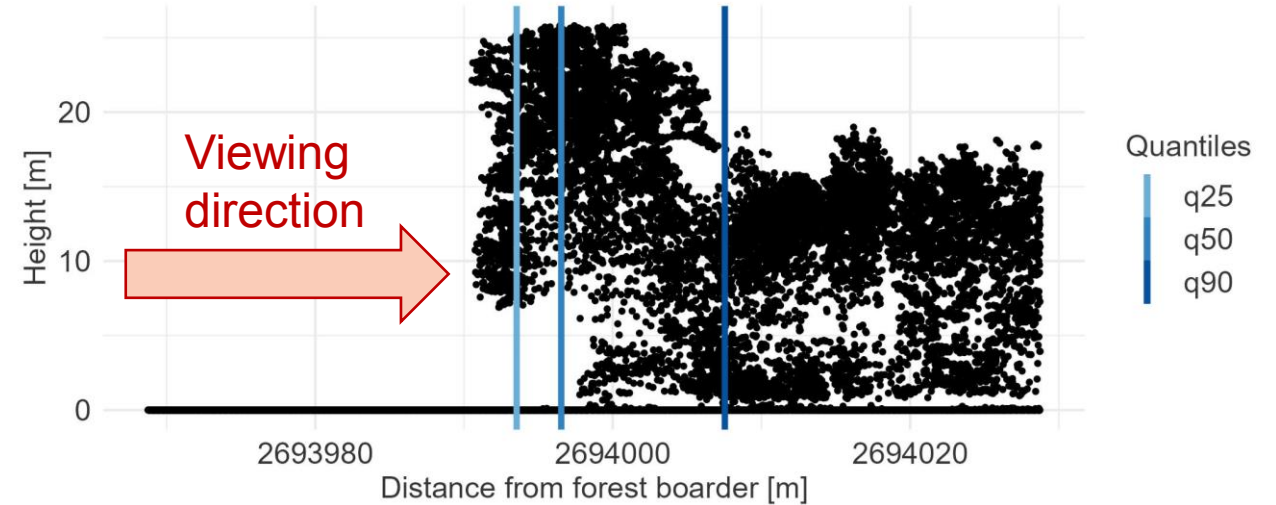
Plot476, depth = 5



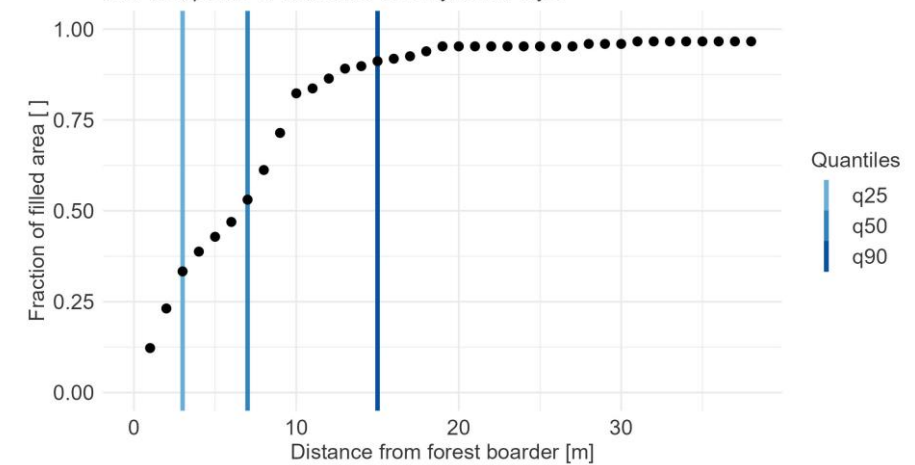
Plot476, depth = 15



Plot 476, profile 3, quantiles of filled area in horizontal direction



Plot 476, profile 3, horizontal visibility, shrub layer



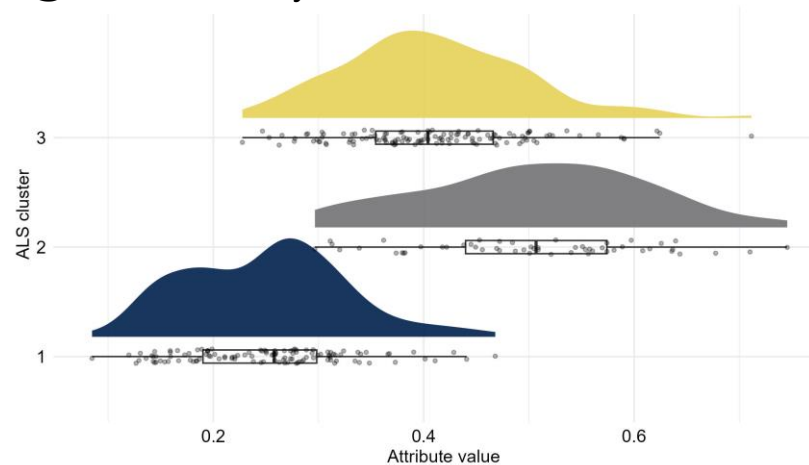
Edge quality assessment

Derivation of edge quality classes

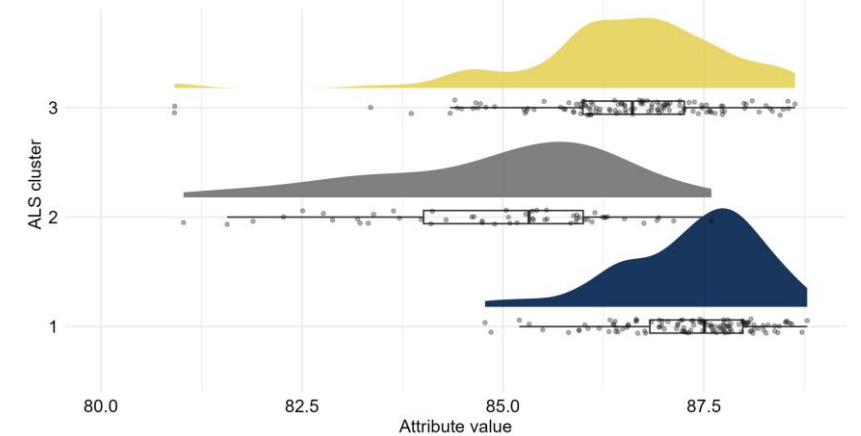
- Clustering based on derived metrics
- Three target classes
- Clusters reflect edge qualities



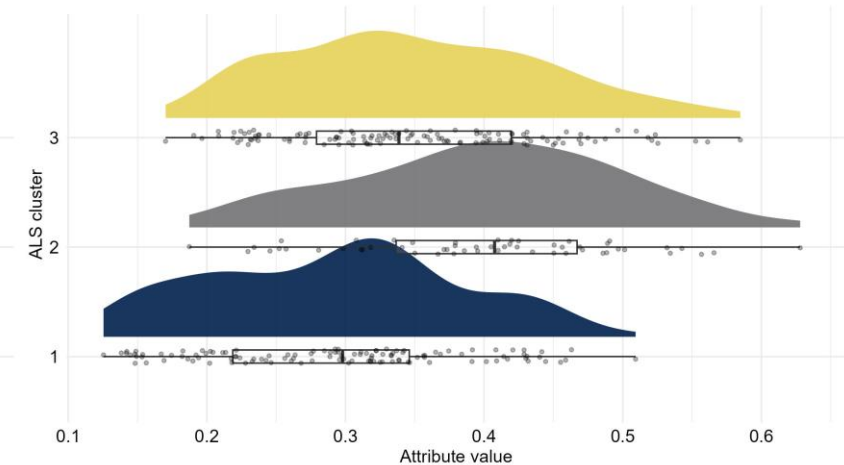
Horizontal visibility (filled voxel space)
@ 5 m, shrub layer



Slope angle

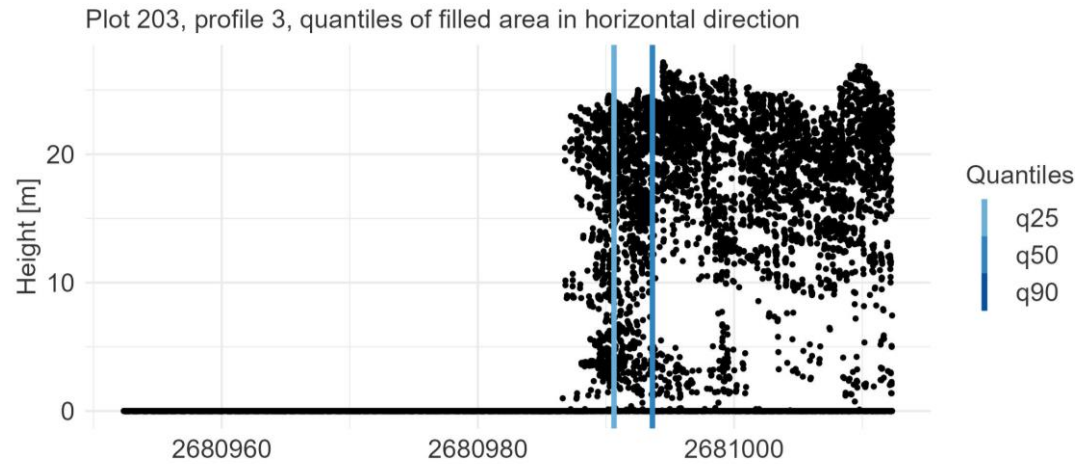


Sky-view factor

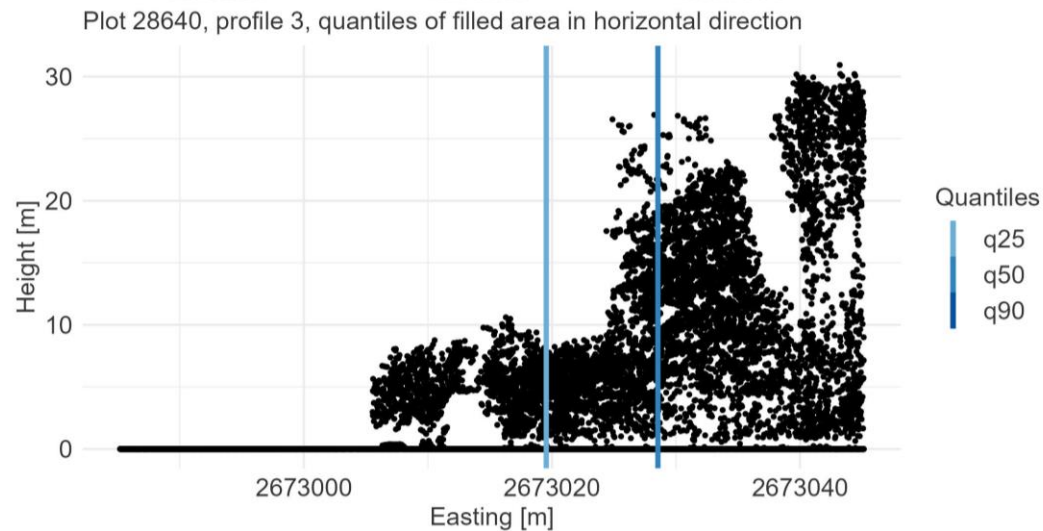


Edge quality assessment

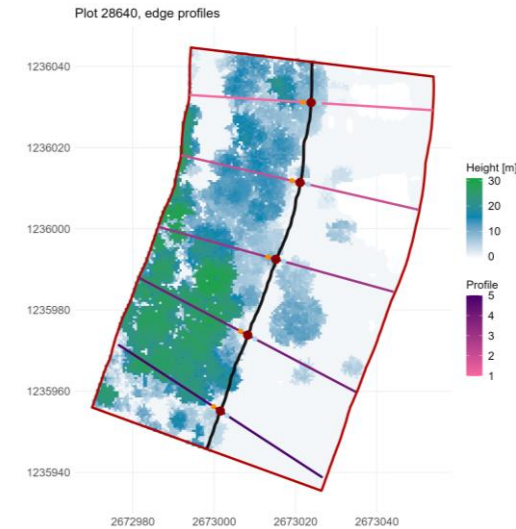
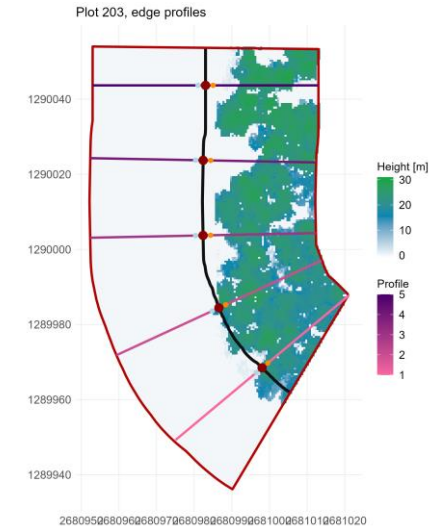
Cluster 1



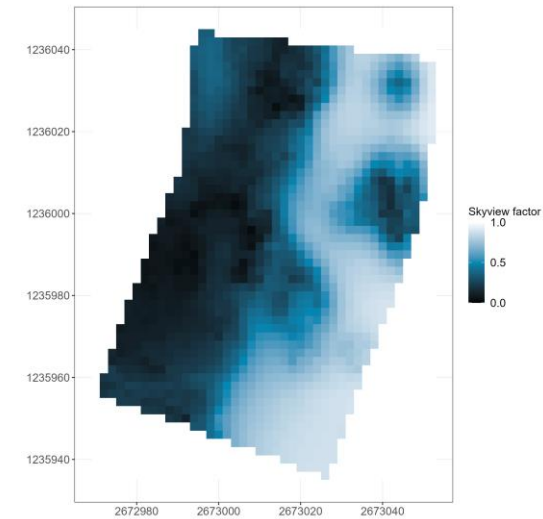
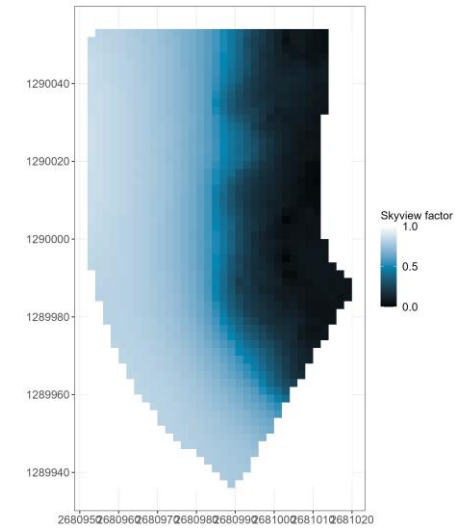
Cluster 2



CHM



Sky-view factor



Conclusions

Usage of ALS Metrics

Advantages

- Objective characterization of forest edges
- Allow monitoring of edge development (e.g. edge revaluation)

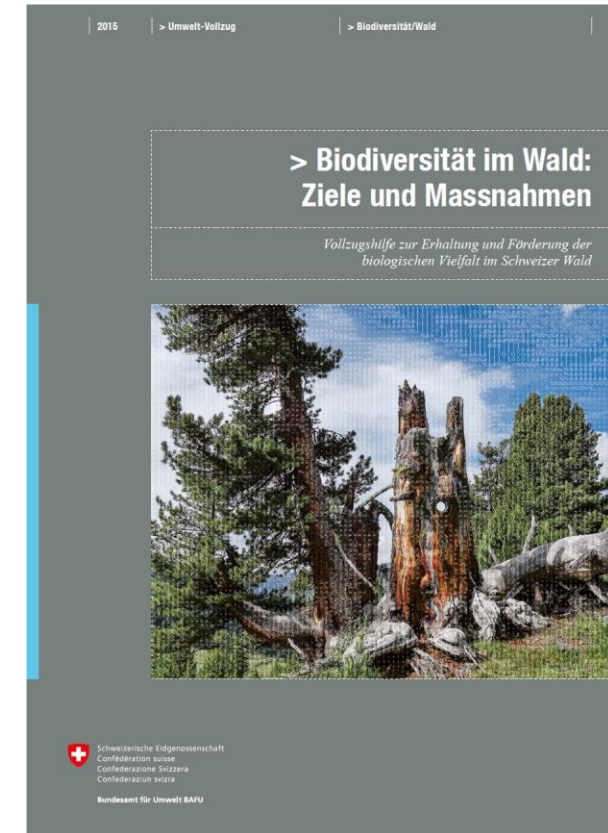
Differences to NFI

- Focus on 3D structure
- Clustering-based quality classes



GIS-basierte Priorisierung der Waldränder im
Kanton St.Gallen

2. aktualisierte Version (2020)





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Thank you for your attention!

E-mail: moritz.bruggisser@wsl.ch



@MoBruggisser
@WSL_RemoteSens