The Habitat Map of Switzerland: data description

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1 Overview

1.1 Objectives

The FOEN funded project 'Developing a Habitat Map of Switzerland' conducted at the WSL, has produced a map of Swiss habitats according to the TypoCH classification (Delarze et al. 2015) wall-to-wall across the whole of Switzerland, to at least the classification's 2nd level of detail (where possible to the 3rd level of detail). This documentation refers to the general user version of the habitat map, published online through the WSL's Virtual Data Centre (VDC) in October 2021.

The implementation of the Habitat Map of Switzerland is a vector data set, where each polygon of the dataset is classified to one habitat type only.

1.2 Method overview

Habitats are mapped through a variety of approaches that can be grouped as either:

1: Derived from the existing Swiss-wide high quality landcover mapping from Swisstopo's Topographical Landscape Model (TLM),

2: Modelled within the project using Random Forest or Ensemble Modelling techniques to model the spatial distribution of individual habitat types (further detail below),

3: Combining existing species distribution models to determine habitat types, or

4: Classification with relatively simple rule-sets based on auxiliary spatial datasets, i.e. vegetation height models, the digital terrain model, the normalised difference vegetation index (NDVI) derived from aerial imagery and/or time-series of growing season Sentinel-2 satellite imagery.

(9: Not included)

Table 1: TypoCH habitat types at the second level and method used in the Habitat Map of Switzerland project to determine their distribution. Habitats highlighted in light grey were modelled to the 3rd level with the same methodology as indicated in the column Method. Habitats in italics and a '9' indicated in the Methods column were not modelled in this version of the Habitat Map. Habitats marked with an asterisk * are those we have plans to improve with newly available data and models from other projects. Those marked with 2 asterisks ** we were not able to model in a satisfactory way in this implementation of the project and for which concentrated improvements are planned for future release of new versions.

TypoCH	TypoCH_DE	TypoCH_FR	TypoCH_IT	Method
1	Gewässer	Eaux libres	Ambienti acquatici	1
1.1	Stehende Gewässer	Eaux calmes	Acque ferme	1
1.2	Fliessgewässer	Eaux courantes	Acque correnti	1
1.3	*Quellen und Quellfluren*	*Sources et suintements*	*Sorgenti e stillicidi*	*9*
1.4	*Unterirdische Gewässer*	*Eaux souterraines*	*Acque sotterranee*	*9*
2	Ufer und der Feuchtgebiete	Rivages et lieux humides	Rive e luoghi umidi	1
2.0	*Künstliche Ufer*	*Rives artificielles*	*Rive artficiali*	*1*
2.1**	Ufer mit Vegetation	Rivages avec végétation	Rive con copertura vegetale	1
2.2	Flachmoore	Bas-marais	Paludi (torbiere basse)	2
2.3	Feuchtwiesen	Prairies humides	Prati acquitrinosi	2
2.4	Hochmoore	Tourbière bomées	Torbiere alte	2
2.5**	Wechselfeuchte Pionierfluren	Végétation annuelle temporairement inondée	Luoghi temporaneamente inondati con vegetazione annuale	2
3	Gletscher, Fels, Schutt und Geröll	Glaciers, rochers, éboulis et moraines	Ghiacciai, rocce, ghiaioni, depositi fluviali e glaciali	1
3.1	Gletscher, Firn- und Schneefelder	Glaciers, névés	Ghiacciai e nevai	1
3.2**	Alluvionen und Moränen	Alluvions et moraines	Suoli alluvionali e morene	1
3.3	Steinschutt- und Geröllfluren	Eboulis	Ghiaioni	1
3.4	Felsen	Parois rocheuses	Pareti rocciose	1
3.5	*Höhlen*	*Grottes et cavernes obscures*	*Grotte, caverne e cunicoli*	*9*
4	Grünland (Naturrasen, Wiesen und Weiden)	Pelouses et prairies	Praterie	2
4.0	Kunstrasen	Gazons et prairies artificielles	Tappeti erbosi e prati artificiali	2
4.1	Pionierfluren auf Felsböden (Felsgrusfluren)	Dalles rocheuses et lapiez	Tavolati e campi solcati	4
4.2	Wärmeliebende Trockenrasen	Pelouses sèches thermophiles	Praterie termofile aride e semiaride	2
4.3	Gebirgs-Magerrasen	Pelouses et pâturages maigres d'altitude	Praterie e pascoli magri d'altitudine	2
4.4**	Schneetälchen	Combes à neige	Vallette nivali	2
4.5	Fettwiesen und -weiden	Prairies grasses	Praterie e pascoli pingui	2
4.6**	Grasbrachen	Friches à graminées	Aree abbandonate erbose	2
5	Krautsäume, Hochstaudenfluren und Gebüsche	Landes, lisières et mégaphorbiaies	Margini di bosco, radure, aggregati di alte erbe, cespuglieti e brughiere	1

5.1	*Krautsäume*	*Lisières herbacées (ourlets)*	*Margini di bosco erbacei*	*9*
5.2**	Hochstauden- und Schlagfluren	Mégaphorbiaies, coupes forestières	Tagli rasi, radure e luoghi con alte erbe	4
5.3**	Gebüsche	Formations buissonnantes (manteau, fourrés, haies)	Cespuglieti (mantelli, spessine, siepi)	1
5.4**	Zwergstrauchheiden	Landes	Brughiere	2
6	Wälder	Forêts	Ambienti boscati	1
6.0	Forstpflanzungen	Plantations	Piantagioni	4
6.1*	Bruch- und Auenwälder	Forêts inondables	Boschi innondabili, alluvionali	3
6.2*	Buchenwälder	Hêtraies	Faggete	3
6.3*	Andere Laubwälder	Autres forêts de feuillus	Altri boschi di latifoglie	3
6.4*	Wärmeliebende Föhrenwälder	Pinèdes thermophiles	Pinete termofile	3
6.5*	Hochmoorwälder	Forêts de tourbières	Boschi di torbiera	3
6.6*	Gebirgsnadelwälder	Forêts de cônifères d'altitude	Boschi di conifere d'altitudine	3
7	Pioniervegetation gestörter Plätze (Ruderalstandorte)	Végétation pionnière des endroits perturbés par l'homme	Ambienti ruderali e perturbati dall'uomo	4
7.1**	Trittrasen und Ruderalfluren	Terrains piétinés et rudéraux	Terreni calpestati e ruderali	4
7.2	*Anthropogene Steinfluren*	*Milieux rocheux anthropogènes*	*Manufatti in sasso, muri e selciati*	*9*
8	Pflanzungen, Äcker und Kulturen	Plantations, champs et cultures	Ambienti coltivati	2
8.1	Baumschulen, Obstgärten, Rebberge	Cultures de plantes ligneuses	Colture di piante legnose	1
8.2*	Feldkulturen (Äcker)	Cultures de plantes herbacées	Colture di piante erbacee	2
9	Bauten, Anlagen	Milieux construits	Ambienti edificati e infrastrutture	1
9.1	Lagerplätze, Deponien	Décharges, dépôts	Discariche, depositi di materiale vario	1
9.2	Bauten	Bâtiment	Edifici	1
9.3	Verkehrswege	Voies de communication	Vie di communicazione	1
9.4	Versiegelter Sportplatz, Parkplatz etc.	Terrain de sport revêtu, place de parc	Campi sportivi, parcheggi pavimentati ecc.	1

1.3 Data structure

The dataset has the following attributes (Table 2). The methodology used to derive the attributes 'Probability' and 'Cover' is described in section xx of this document.

Table 2: Dataset attributes

Attribute	Attribute_DE	Attribute_FR	Type	Examples	Explanation
TypoCH	TypoCH	TypoCH	Int	1, 65, 451	Integer code representing the TypoCH number code at the highest level available
Class	Bereich	Zone	Int	1,2,3,4…9	Code for the top level of the TypoCH system, Class
Group	Gruppe	Groupe	Int	12, 21, 34, 45…	Code for the 2nd level of the TypoCH system, Group. Class code when no 2nd level classification is available
Type	Typ	Type	Int	232, 451, 633	Code for the 3rd level of the TypoCH system, Type. Group/Class code when no 3rd level classification is available
TypoCH_DE	TypoCH_DE	TypoCH_DE	text	1.1 Stehende Gewässer	Name of TypoCH number in German
TypoCH_FR	TypoCH_FR	TypoCH_FR	text	1.1 Eaux calmes	Name of TypoCH number in French
TypoCH_IT	TypoCH_IT	TypoCH_IT	text	1.1 Acque ferme	Name of TypoCH number in Italian
TypoCH_Sci	TypoCH_Sci	TypoCH_Sci	text	Carpinion	Latin name of Habitat type, when available
Source	Quelle	Source	Int	1, 2, 3, 4	code for data source 1: TLM, 2: WSL Modelling, 3: Combination of existing models, 4: Ruleset
Prob	Wahrscheinlichkeit	Probabilité	Int	1, 2, 3, 9999	Code for model probability 1: low probability, 2: medium probability, 3: high probability. Only for wetland, grassland, shrub forest (539, 54), arable land (8.2) and forest classes, all others have 9999 unknown
Cover	Anteil	Proportion	float	0.67, 0.82	Percentage area of polygon covered by this class according to the models. Only for wetland, grassland, shrub forest (539, 54), arable land (8.2) and forest classes, all others have 9999 unknown

2 Methods

2.1 Overall approach

The base data for the habitat map of Switzerland is the 1m resolution airborne orthoimagery. The overall general workflow for producing the Habitat Map is show in Figure 1. Within the software eCognition, the orthoimagery is segmented into 'image primitives' on the basis of the reflectance in the RGB and NIR bands, and values of the metric NDVI. In a rule-based approach, habitat types are assigned to segments based on the input data and distribution models, which, depending on habitat types, come from one of the four approaches listed above in section 1.2. If multiple habitat types could be potentially present within an image segment (according to the different distribution models), the assignment to a habitat class is in general based on majority coverage by area.

Once each image segment is assigned a habitat class within the eCognition software, segments are dissolved according to habitat type. Then, the segments are exported to ArcGIS for smoothing and cleaning. Finally, the

dataset is overlaid with small features from the TLM – roads, buildings, railways, smaller river features (with a constant 1m buffer), and small scale land use features from TLM, see Table 3 for details.
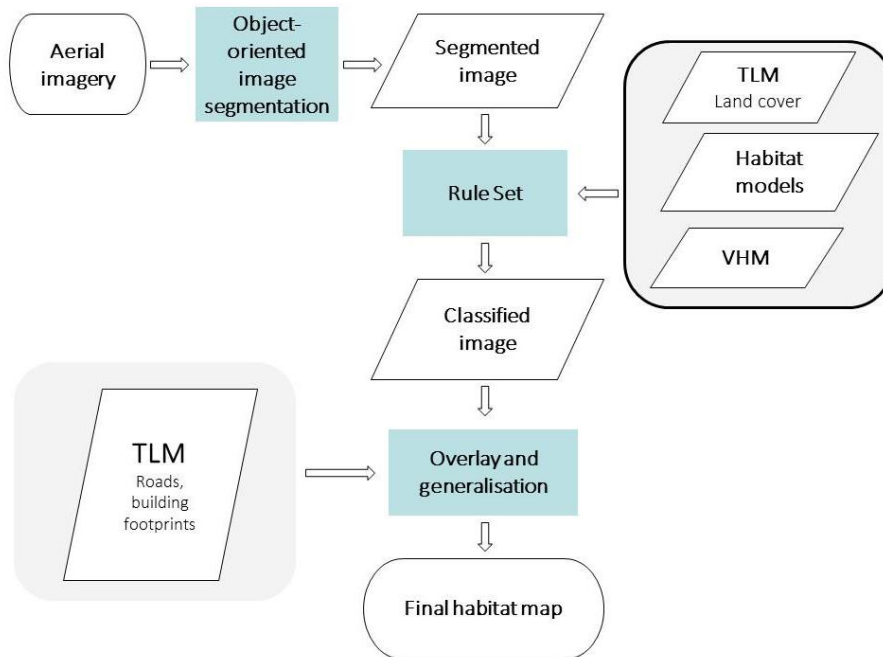

Figure 1: Overview of the methodological workflow for producing the Habitat Map of Switzerland

2.2 Method details

2.2.1 Approach 1: TLM

Table 3 details the habitat groups and types that are adopted directly from the TLM and lists the source TLM datasets.

2.2.2 Approach 2: WSL Modelling

2.2.2.1 Wetlands (2.2, 2.3, 2.4), Grasslands (4.0, 4.2, 4.3, 4.4, 4.5, 4.6) and Dwarf Shrubs (5.4)

An ensemble modelling approach was used to model the distribution of wetland and grassland habitat types at the level of the habitat type (3rd level). Training data samples were compiled from various data sources, predominantly vegetation surveys. Sentinel 1 backscatter products and Sentinel-2 indices as well as variables describing climate, soil properties and topography were used as predictors. For inclusion into the Habitat Map, the maps of the individual habitat types (with the exception of snow bed communities 4.4) were combined into an overall grassland and wetland habitat map differentiating 20 habitat types at a 10x10 m resolution. Full details can be found in Huber et al. (in prep).

For the snow bed communities (4.4), the ensemble distribution maps were combined with polygons featuring long snow cover detected with high temporal resolution satellite imagery (Planet). This pilot approach requires additional validation and incorporation of longer time series of image data.

For dwarf shrubs (5.4), the same modelling procedure was applied as for the wetland and grassland habitat types. The training samples were provided from aerial image interpretation. As additional predictors, texture variables derived from the 1m resolution airborne orthoimagery were used. The models refer to the TypoCH types 5.4.3, 5.4.4 and 5.4.5, while the types 5.4.1, 5.4.2 and 5.4.6 are not captured.

Table 3: Included TLM data with source dataset and how each is translated to TypoCH. The dataset TLM_BODENBEDECKUNG is used in an initial coarse eCognition segmentation. Asterisked* classes are then further classified using the Methodological approaches 2, 3 or 4. All other TLM dataset indicated in the table are incorporated as an overlay, post eCognition processing.

TLM Dataset	OBJEKTART	Description	TYPOCH	TYPOCH_Name
TLM_BODENBEDECKUNG	1*	Fels	34	Felsen
TLM_BODENBEDECKUNG	2*	Fels locker	33	Steinschutt- und Geröllfluren
TLM_BODENBEDECKUNG	3*	Felsblöcke	33	Steinschutt- und Geröllfluren
TLM_BODENBEDECKUNG	4*	Felsblöcke locker	33	Steinschutt- und Geröllfluren
TLM_BODENBEDECKUNG	5	Fliessgewässer	12	Fliessgewässer
TLM_BODENBEDECKUNG	6	Gebüschwald	53	Gebüsche
TLM_BODENBEDECKUNG	7*	Lockergestein	33	Steinschutt- und Geröllfluren
TLM_BODENBEDECKUNG	8*	Lockergestein locker	33	Steinschutt- und Geröllfluren
TLM_BODENBEDECKUNG	9	Gletscher	31	Gletscher, Firn- und Schneefelder
TLM_BODENBEDECKUNG	10	Stehende Gewässer	11	Stehende Gewässer
TLM_BODENBEDECKUNG	11*	Feuchtgebiete	2	Feuchtgebiete
TLM_BODENBEDECKUNG	12*	Wald	6	Wälder
TLM_BODENBEDECKUNG	13*	Wald offen	6	Wälder
TLM_BODENBEDECKUNG	14*	Geholzfläche with VHM >3m, VHM<3m	600, 53	Nichtwaldbäume, Gebüsche
TLM_STRASSE	all	with Belegsart = 100	932	Asphalt- oder Betonstrasse
TLM_STRASSE	all	with Belegsart = 200	933	Naturstrasse, Weg
TLM_EISENBAHN	all		934	Bahngleis
TLM_GEBAEUDE_FOOTPRINT	all <> 16	Gebäude	92	Bauten
TLM_SPORTBAUTE	0 (with mean NDVI < 0.1)	Sportplatz	94	Versiegelter Sportplatz, Parkplatz usw.
TLM_SPORTBAUTE	1 (with mean NDVI > 0.1)	Sportplatz	402	Kunstrasen auf Sportplätzen, im Siedlungsraum usw.
TLM_STAUBAUTE	0	Staumauer	9	Bauten
TLM_VERKEHRSBAUTE	1	Staudamm	9	Bauten
TLM_VERKEHRSBAUTE	2	Wasserbecken	11	Stehendes Wasser
TLM_VERKEHRSBAUTE	3	Wehr	9	Bauten

TLM_VERKEHRSBAUTE	2	Graspiste	402	Kunstrasen auf Sportplätzen, im Siedlungsraum usw.
TLM_VERKEHRSBAUTE	3	Hartbelagpiste	932	Asphalt- oder Betonstrasse
TLM_VERKEHRSBAUTE	4	Perron	93	Verkehrswege
TLM_VERKEHRSBAUTE	5	Rollfeld Gras	402	Kunstrasen auf Sportplätzen, im Siedlungsraum usw.
TLM_VERKEHRSBAUTE	6	Rollfeld Hartbelag	932	Asphalt- oder Betonstrasse
TLM_VERKEHRSBAUTE	7	Schleuse	12	Fliessgewässer
TLM_NUTZUNGSAREAL	3	Baumschule	81	Baumschule, Obstgarten, Rebberge
TLM_NUTZUNGSAREAL	9	Kehrrichtverbrennungsareal	9	
TLM_NUTZUNGSAREAL	15	Obstanlage	81	Baumschule, Obstgarten, Rebberge
TLM_NUTZUNGSAREAL	17	Reben	816	Rebberge
TLM_NUTZUNGSAREAL	18	Schrebergartenareal	823	Hackfruchtacker (Sommerkultur), Garten
TLM_NUTZUNGSAREAL	23	Unterwerkareal	92	Fabrik, Halle, Lagerhaus (9243/4 Kraftwerk)
TLM_NUTZUNGSAREAL	5	Oeffentliches Parkplatzareal	94	versiegelter Sportplatz, Parkplatz, usw.
TLM_NUTZUNGSAREAL	*all others not included*			
TLM_VERKEHRSAREAL	10	Privates Parkplatzareal	94	versiegelter Sportplatz, Parkplatz, usw.
TLM_VERKEHRSAREAL	*all others not included*			
TLM_FREIZEIT_AREAL	*not included*			

2.2.2.2 Shrub forest (5.3.9, 5.4)

Models of the distribution of Green alder shrub forest (TypoCH 5.3.9) and mountain pine shrubs (*Pinus mugo* ssp. *mugo*) developed by Rüetschi et al (in prep); Weber et al (2021) were integrated into the Habitat Map. Thereby, the mountain pine shrubs were added as TypoCH 5.4 to the ensemble models described in *2.2.2.1*. The shrub models are random forest models, using NFI plot and image interpretation training data, and VHM, Sentinel 1 and 2 satellite imagery explanatory data. Methodological details can be found in Rüetschi et al. (in review) and Weber et al. (2021).

2.2.2.3 Arable land (8.2)

To identify arable land (8.2), the distribution of cropland and grassland was mapped across Switzerland. Several indices, largely derived from Sentinel-2 satellite imagery, were used as predictors. Parcel-based training data were derived from landholder reporting. The mapping was conducted within Google Earth Engine using a random forest classifier. The classifier was trained separately for the lowlands and the Alps. Further details are available in Pazur et al., in review.

2.2.3 Approach 3: Combination of existing models

Mapping of class 6 Forest habitat types relied on existing spatially explicit models of forest tree species. Within the WSL, there are a number of previous and ongoing projects mapping distributions of forest species/communities/types (e.g., Wüest and Baltensweiler 'Modellierte Verbreitungskarten für die häufigsten Gehölzarten der Schweiz' (MoGLI); Waser et al. 'Exploiting the full potential of Copernicus Sentinel data for countrywide tree species mapping'; Scherrer et al. 'Modelling of potential natural forest communities across Switzerland based on NFI-Data'). Therefore, instead of building new models within this project, we relied on the existing modelling outputs from the MoGLI project (Wüest el al. 2021), with a view to improving the mapping of forest habitats as the results of the ongoing projects are released in the coming years (Waser et al; Scherrer et al.).

The MoGLI project model the 70 most common tree species of Switzerland. For each of the TypoCH forest habitat types at the second level, we identified the character and indicator species for which a MoGLI model was available. We then combined these models so that the distribution of the habitat type was defined as the areas where the distribution models of all available character and indicator species intersected one another.

2.2.4 Approach 4: Rulesets

Some habitat types are defined using a rule-based approach within the eCognition classification. Here, auxiliary datasets including the Digital Terrain Model (25m resolution), Vegetation Height Models of 2012 and 2019, and time series of growing season NDVI derived from 4 years (2017-2020) of Sentinel-2 imagery are used as input to classification rules. These rules are summarized in Table 4 for the relevant habitat classes.

Table 4: Ruleset

TypoCH	Classification rule
4.1 Pionierfluren auf Felsböden	TLM_BB Fels (1) with median growing season NDVI (Sentinel-2)
5.2 Hochstauden- und Schlagfluren	TLM_BB Forest (12,13) with mean VHM 2012 > 3m and mean VHM 2019 <3m
5.3.0 Hecken und Gebüsche ausserhalb Gebüschwald	No classification in the TLM_BB with median VHM 2019 >1.5m and median VHM2019 <3m mean NDVI (aerial imagery) > 0.2
6.0.0 Nichtwaldbäume	No classification in the TLM_BB with median VHM 2019 >3m and mean NDVI (aerial imagery) > 0.2
7.1 Trittrasen, Ruderalfluren	

2.2.5 Cover and Probability

<u>Probability</u>
Probability was calculated for those habitats that were modelled within the project (Methods 2 or 3).

For Cropland (Group 8.2), Wetland and Grassland (Classes 2 and 4) and shrubs (5.3.9 and 5.4), a probability of occurrence was derived directly from the Random Forest or ensemble models. In each case, a mean probability was calculated for each eCognition segment. These probabilities were reclassified to 3 classes so that probability 0-0.5 = 1, 0.5-0.75 = 2 and greater than 0.75 = 3.

For forest habitat types, probability 3 (high likelihood) is assigned to pixels where the MoGLI distribution for all available indicator and character species for the habitat type overlap. Probability class 2 is assigned to pixels that were classified to a given habitat type due to being within a segment with majority cover of that habitat type according to the combined MoGLI model, but not containing all of the indicator and character species distributions itself. All other forest pixels were assigned the low probability class (1). These are, for example, segments assigned to a given habitat type because of their neighbourhood classification.

<u>*Cover*</u>
As with Probability, the Cover variable was calculated for the habitat types that were modelled within the project. We are three combination maps: grassland and wetland, Shrub Forest and Forest, within which each pixel contains only one habitat type. Then, the Cover variable for the habitat type assigned was derived from a calculation of the percentage area of the eCognition segment polygon in which the assigned habitat type was predicted to be present.

2.2.6 Validation

For the habitat types modelled with approach 2, model validation was performed against independent data (see publications for details (Huber et al, in prep; Pazur et al. in review; Rüetschi et al. in review; Weber et al 2021).

In addition, plausibility analyses were performed within the project with a group of expert stakeholders. This included two expert workshops and numerous validation analyses on case areas for locations that were well known to the experts, as well as methodological discussions.

3 Discussion

3.1 Limitations

Users should be aware of the following limitations of the dataset:

- the map does not represent vegetation surveys in the field, but relies on modelled and rule based assignment of habitat types (not necessarily correct)
- it is made with nation-wide available data; thus may not able to represent regional distinctions (for some regions better, for others worse)
- habitat types are not mapped completely (i.e., not all bushes/hedges included)
- not all habitats are represented; and not all with same precision
- in urban areas the map is less detailed due to the large degree of human modification of those landscapes which we could not accurately represent with in our model based approaches. Urban and peri-urban areas will be a focus for improvements in any next version of the Habitat Map
- The map is only applicable within the border of Switzerland.

3.2 Further information

It is planned to provide a more detailed Habitat Map with additional attributes (e.g., more details on uncertainties; 2nd most probable habitat types, etc.) for expert users in 2022.

4. References

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