nFIESTA

Origins, motivation, current and upcoming capabilities of

the new Forest Inventory, Estimation and Analysis framework

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nFIESTA

Origins, motivation, current and upcoming capabilities of
the new Forest Inventory, Estimation and Analysis framework

Contents

- the past
- the present
- the near future

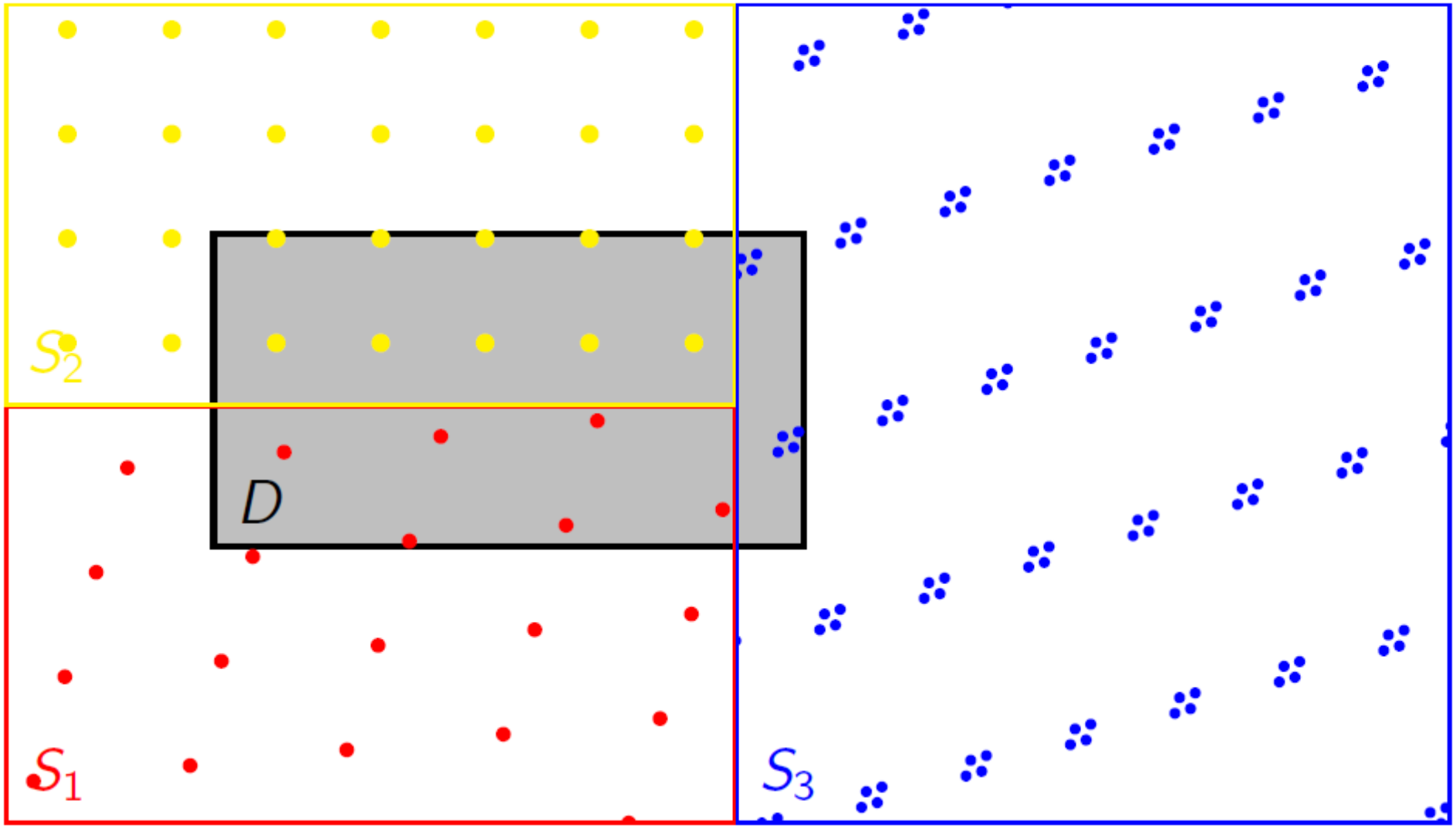
} of the nFIESTA

nFIESTA

- Is a union of **methodological approaches and a software platform** (PostgreSQL DB extensions and GUI front-ends) distributed under the **EUPL licence**;
- Implements **generic and flexible estimation procedures based on probability samples of any variable(s) in a geographical domain** (two-dimensional space);
- Produces **statistically-sound estimates for pooled probability samples**, typically National Forest Inventory (NFI) data, which may come from two or more countries, each of them using a different, but still a probability sampling design;

nFIESTA

- **Does not process (raw) remote sensing data and does not produce any maps.**
- It eventually **integrates remote sensing products (maps) with field-plot data** to get the best of this combination **i.e. (preferably) design-based i.e. unconditionally trustful estimates** for an arbitrary area of interest and period.
- **Model based-estimates can be produced if field-plot data is missing or if the sample size is not sufficient** (given the temporal and spatial definition of the estimation domain).



D domain of interest (estimation cell)

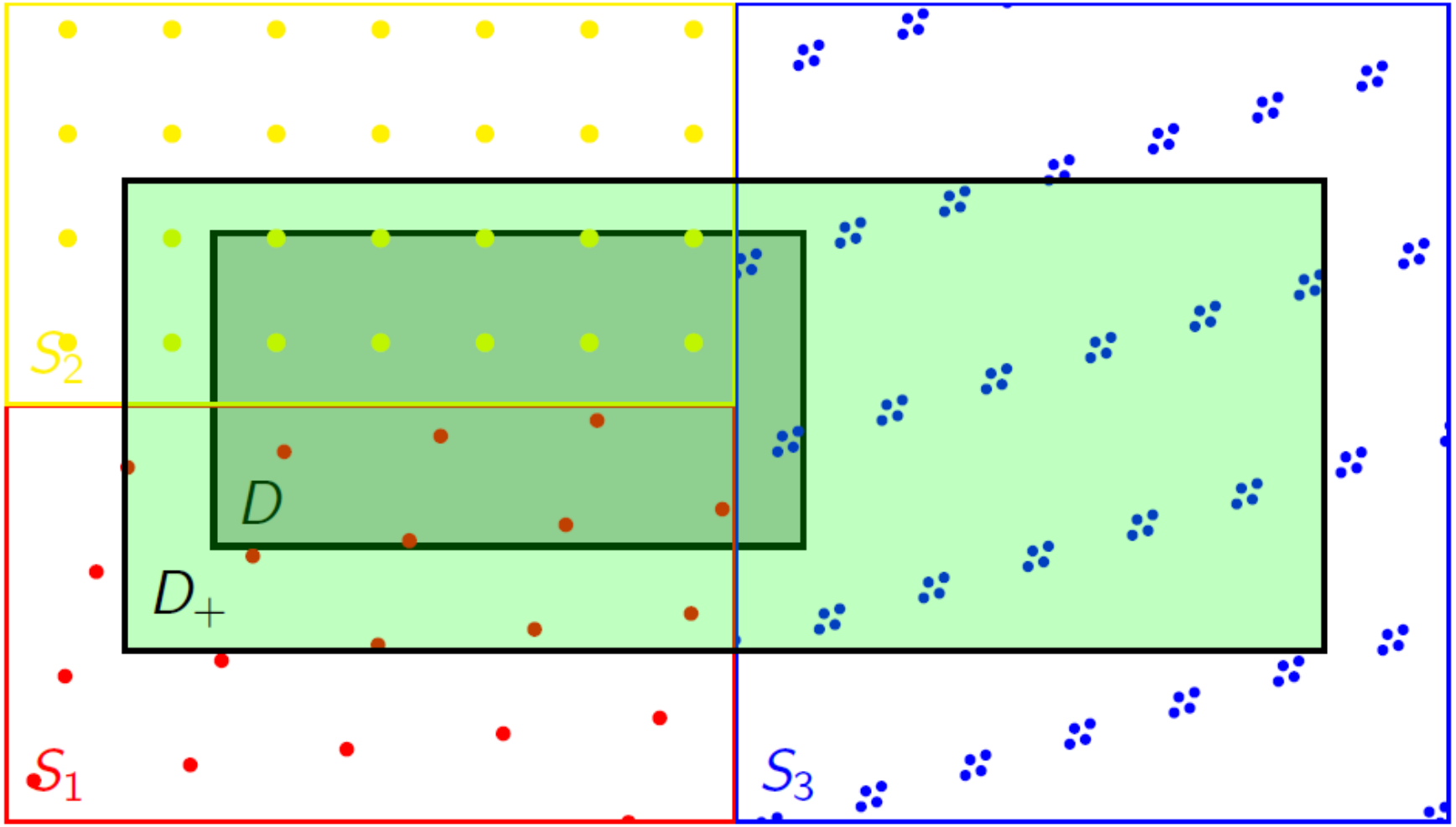
S_j sampling strata (NFI)

nFIESTA

- What nFIESTA offers is in principle the same as what NFIs do in individual MS;
- It implements the best NFI practices of producing the forest related information to be used for strategic planning and policy formulation;
- Unlike the NFIs, nFIESTA can produce the information irrespective of country borders;
- However, nFIESTA needs NFI data to work!
- It can, but does not necessarily have to, incorporate maps to improve the accuracy of information provided (estimates).

nFIESTA [the past]

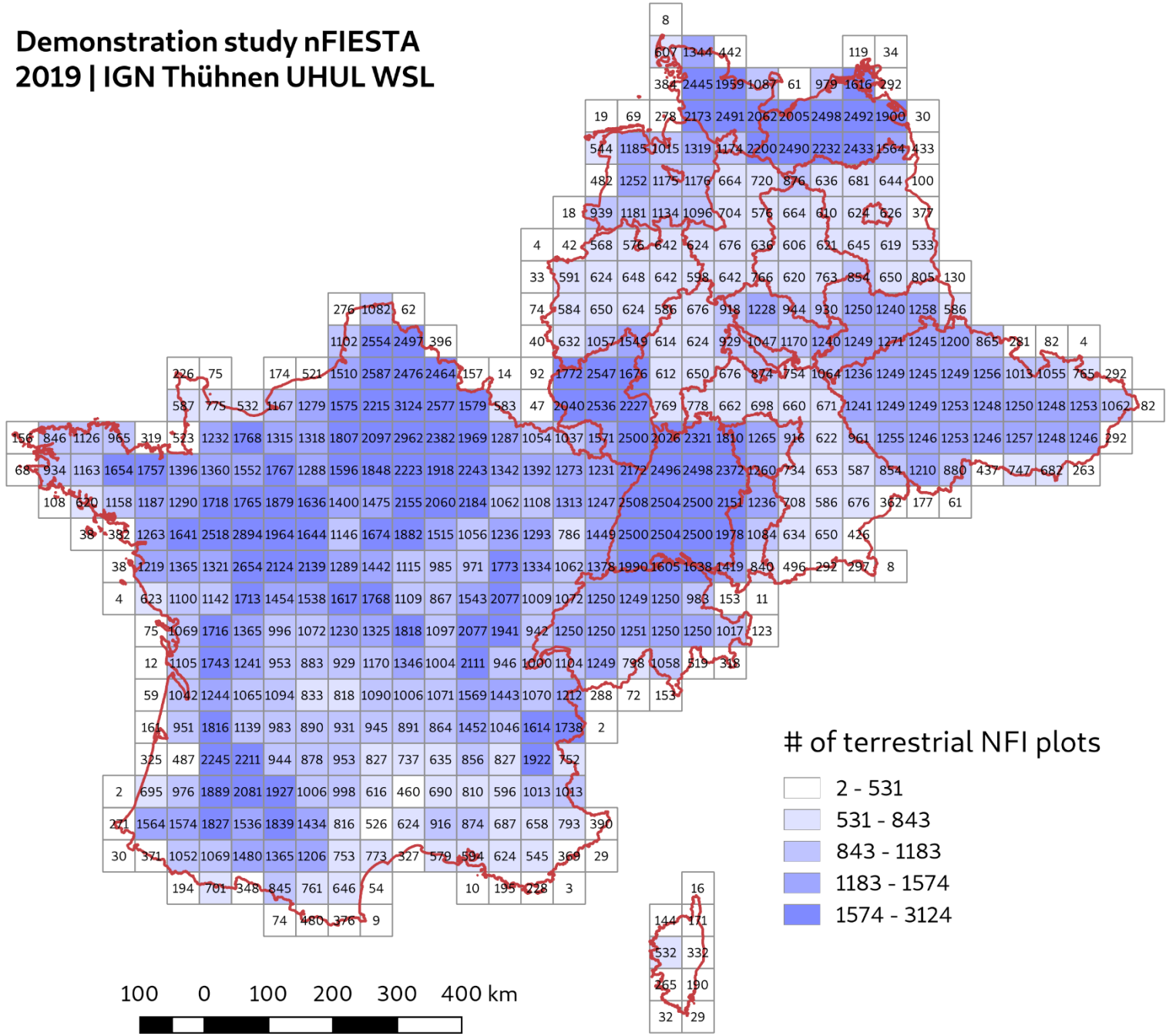
- Was developed as part of DIABOLO project financed by the EU's H2020 research and innovation programme;
- **ENFIN efforts in joint provision of harmonised forest information across Europe**;
- **Further development of an already productive system (eForest)** so far providing estimates based on terrestrial NFI plot data only (2013);
- **Integration of auxiliaries e.g. remote sensing wall-to-wall maps** to increase accuracy and availability of statistically-sound estimates (2018);
- A demonstration study **(F, GER, CH, CZ, over 500 thousand NFI plots) on ABG biomass single-phase and model-assisted estimation** using NFI plot data and **COPERNICUS products / FTY and TCD 2012 (Langanke, 2017)**.



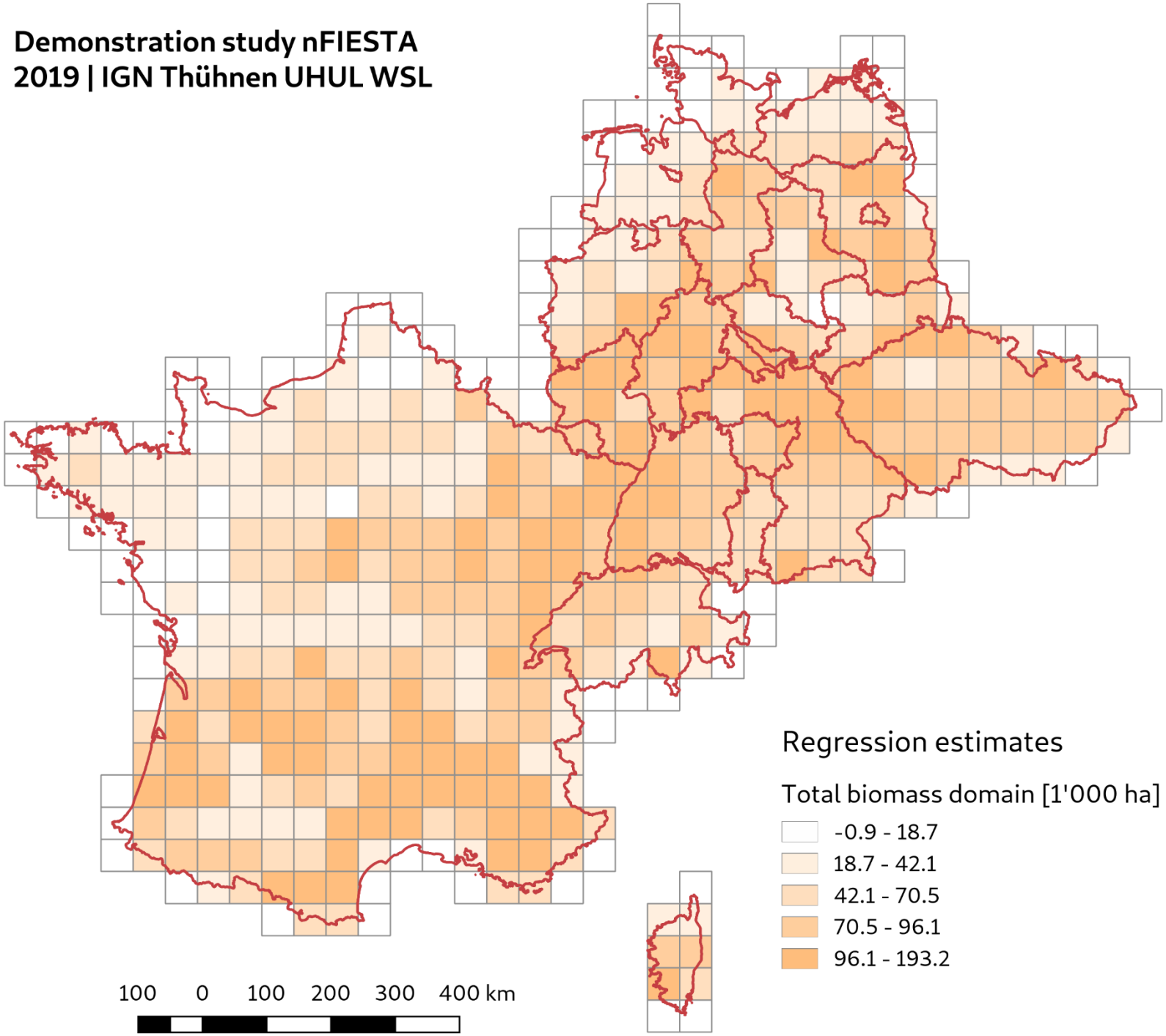
D domain of interest (estimation cell)

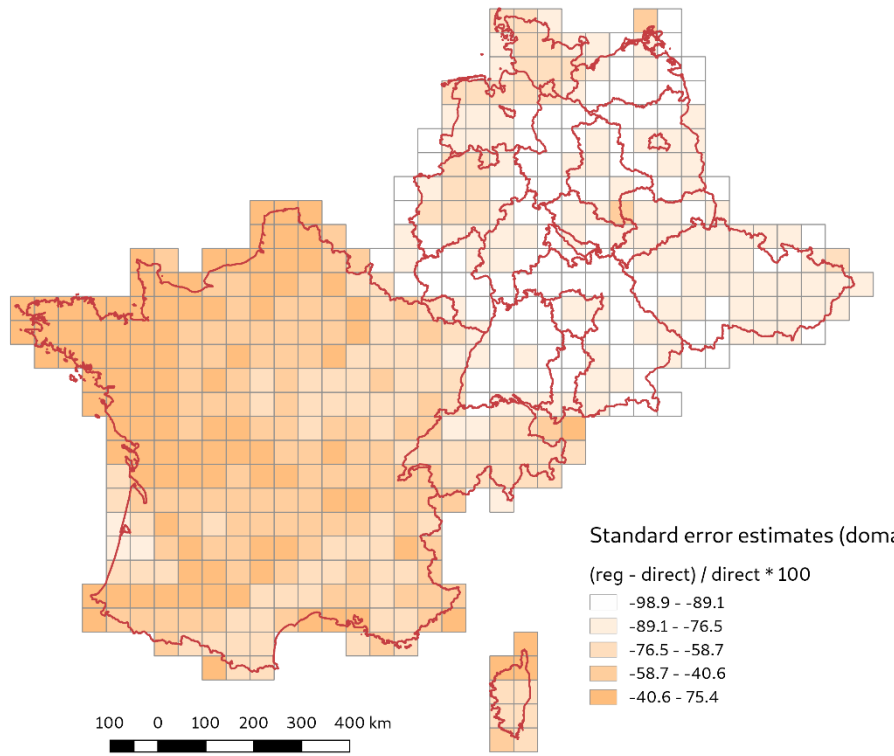
S_j sampling strata (NFI)

D_+ domain for borrowing strength (model parametrisation area)

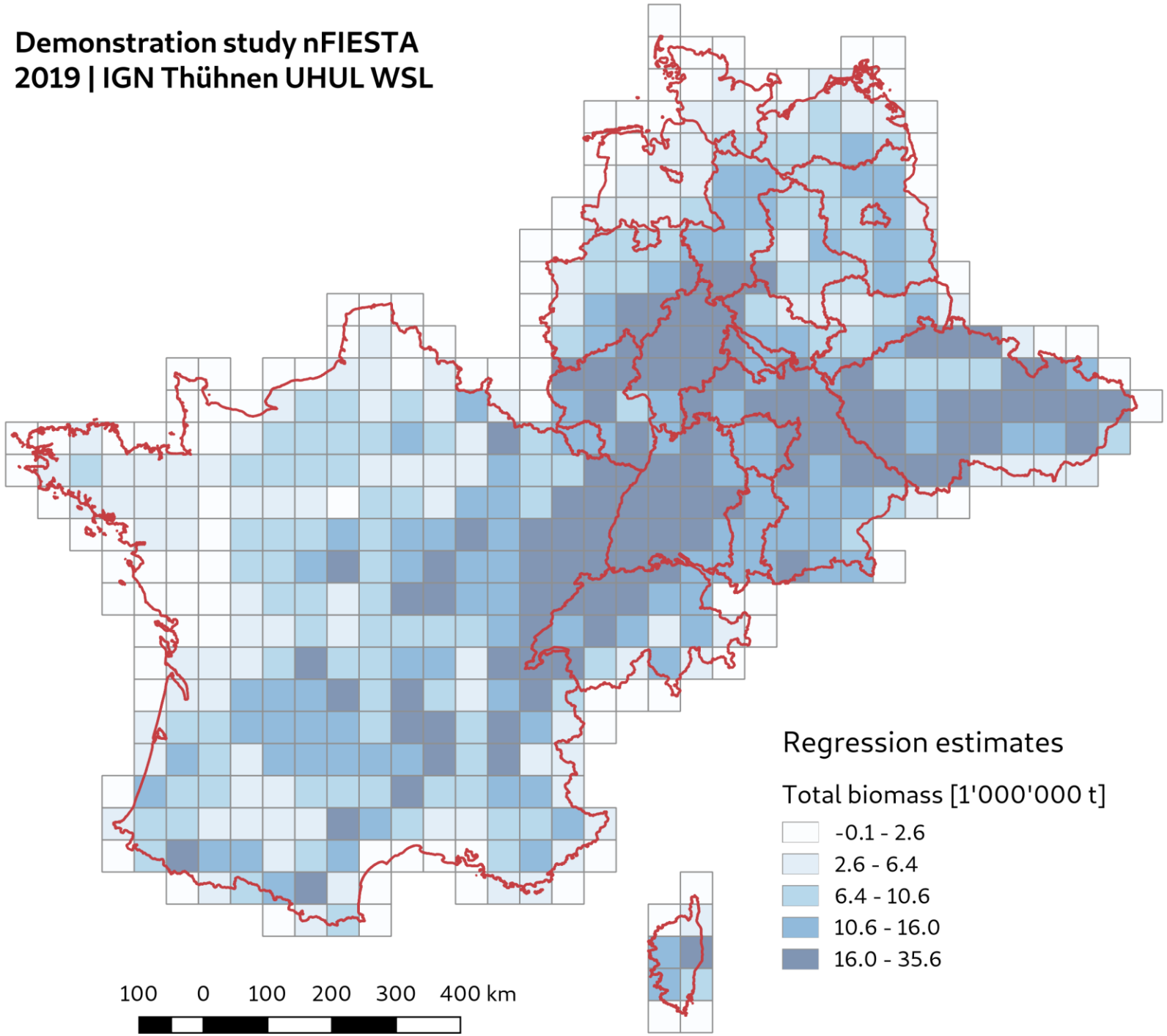

Demonstration study nFIESTA
2019 | IGN Thühnen UHUL WSL
# of terrestrial NFI plots
2 - 531
531 - 843
843 - 1183
1183 - 1574
1574 - 3124
100 0 100 200 300 400 km

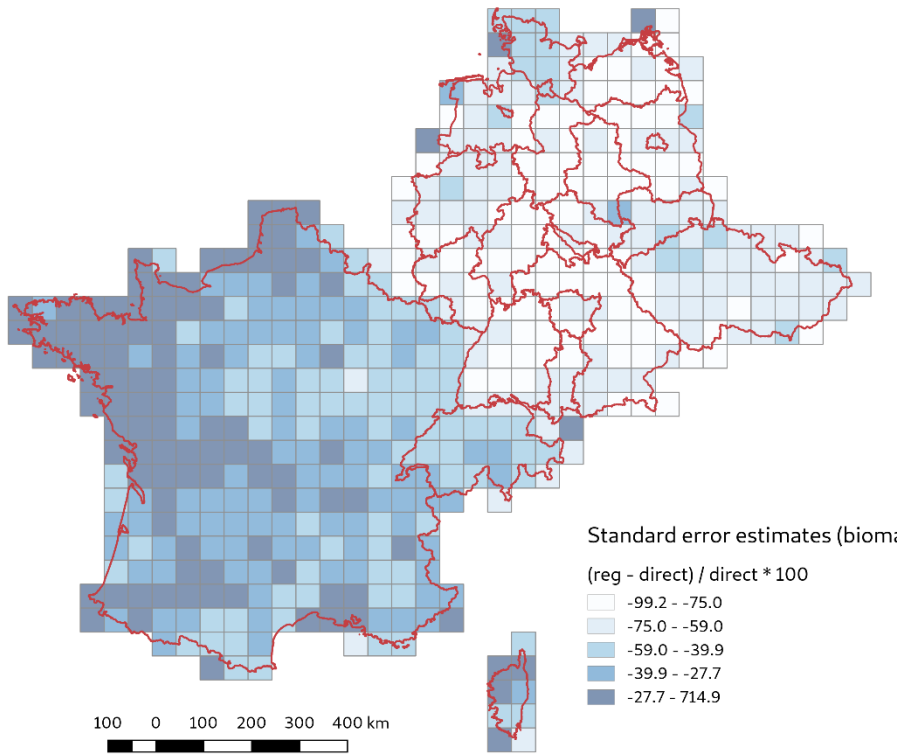
Demonstration study nFIESTA
2019 | IGN Thühnen UHUL WSL





Demonstration study nFIESTA
2019 | IGN Thühnen UHUL WSL



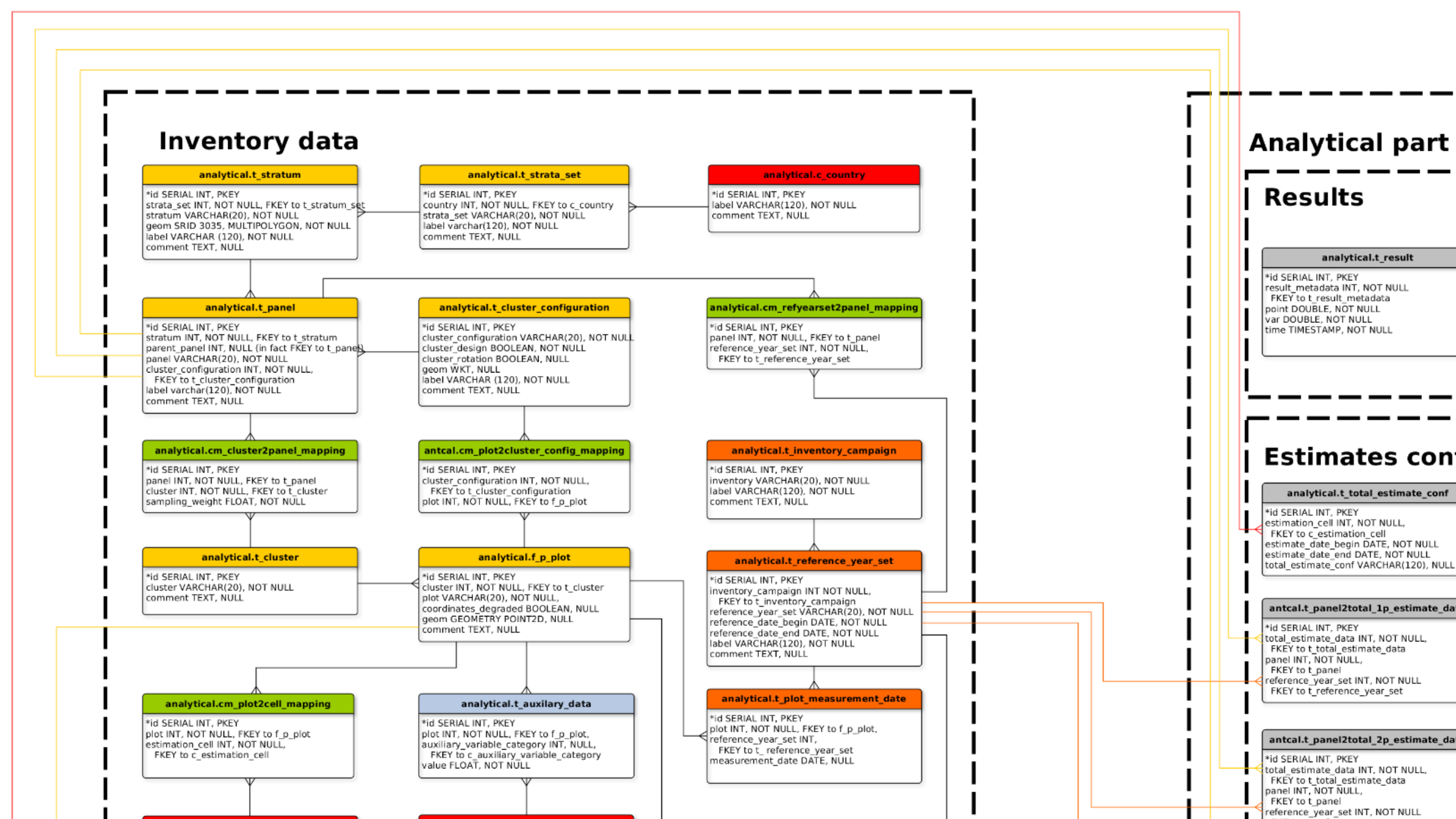


nFIESTA [the past]

- Part I of the **DIABOLO** D2.10 technical report **proposed methods integrating NFI field data and auxiliaries from various time points to produce an up-to-date information on status and changes of forests**;
  - The underlying methodological principle is the **infinite population approach to forest inventory** as presented by **Mandallaz (1991, 2008)** and **Eriksson (1995)**;
  - The principle was further generalised by **the Horvitz-Thomson theorem for point sampling from continuous universe (Cordy, 1993)**;
- Part II of D2.10 technical report specifies **methods implemented within DIABOLO**, i.e. **single-phase estimators, eventually using auxiliaries i. e. model-assisted and model-based (synthetic) estimators** (the later for no field-data scenarios).

nFIESTA [the past]

- Part III of the DIABOLO D2.10 technical report contains full information on the already mentioned demonstration study;
- Appendix A describes **generic data and metadata structures in a form of CSV files**, **capable to hold any field-plot and auxiliary data as well as any NFI design metadata**;
- Appendix B is dedicated to the **functional description of the nFIESTA software platfrom** as it was by the end of DIABOLO (2018).


Inventory data
analytical.t_stratum
*id SERIAL INT, PKEY
strata_set INT, NOT NULL, FKEY to t_stratum_set
stratum VARCHAR(20), NOT NULL
geom SRID 3035, MULTIPOLYGON, NOT NULL
label VARCHAR (120), NOT NULL
comment TEXT, NULL
analytical.t_strata_set
*id SERIAL INT, PKEY
country INT, NOT NULL, FKEY to c_country
strata_set VARCHAR(20), NOT NULL
label varchar(120), NOT NULL
comment TEXT, NULL
analytical.c_country
*id SERIAL INT, PKEY
label VARCHAR(120), NOT NULL
comment TEXT, NULL
analytical.t_panel
*id SERIAL INT, PKEY
stratum INT, NOT NULL, FKEY to t_stratum
parent_panel INT, NULL (in fact FKEY to t_panel)
panel VARCHAR(20), NOT NULL
cluster_configuration INT, NOT NULL,
FKEY to t_cluster_configuration
label varchar(120), NOT NULL
comment TEXT, NULL
analytical.t_cluster_configuration
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cluster_configuration VARCHAR(20), NOT NULL
cluster_design BOOLEAN, NOT NULL
cluster_rotation BOOLEAN, NULL
geom WKT, NULL
label VARCHAR (120), NOT NULL
comment TEXT, NULL
analytical.cm_refyearset2panel_mapping
*id SERIAL INT, PKEY
panel INT, NOT NULL, FKEY to t_panel
reference_year_set INT, NOT NULL,
FKEY to t_reference_year_set
analytical.cm_cluster2panel_mapping
*id SERIAL INT, PKEY
panel INT, NOT NULL, FKEY to t_panel
cluster INT, NOT NULL, FKEY to t_cluster
sampling_weight FLOAT, NOT NULL
antcal.cm_plot2cluster_config_mapping
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cluster_configuration INT, NOT NULL,
FKEY to t_cluster_configuration
plot INT, NOT NULL, FKEY to f_p_plot
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inventory VARCHAR(20), NOT NULL
label VARCHAR(120), NOT NULL
comment TEXT, NULL
analytical.t_cluster
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cluster VARCHAR(20), NOT NULL
comment TEXT, NULL
analytical.f_p_plot
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cluster INT, NOT NULL, FKEY to t_cluster
plot VARCHAR(20), NOT NULL,
coordinates_degraded BOOLEAN, NULL
geom GEOMETRY POINT2D, NULL
comment TEXT, NULL
analytical.t_reference_year_set
*id SERIAL INT, PKEY
inventory_campaign INT NOT NULL,
FKEY to t_inventory_campaign
reference_year_set VARCHAR(20), NOT NULL
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reference_date_end DATE, NOT NULL
label VARCHAR(120), NOT NULL
comment TEXT, NULL
analytical.cm_plot2cell_mapping
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plot INT, NOT NULL, FKEY to f_p_plot
estimation_cell INT, NOT NULL,
FKEY to c_estimation_cell
analytical.t_auxilary_data
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plot INT, NOT NULL, FKEY to f_p_plot,
auxiliary_variable_category INT, NULL,
FKEY to c_auxiliary_variable_category
value FLOAT, NOT NULL
analytical.t_plot_measurement_date
*id SERIAL INT, PKEY
plot INT, NOT NULL, FKEY to f_p_plot,
reference_year_set INT,
FKEY to t_ reference_year_set
measurement_date DATE, NULL
Analytical part
Results
analytical.t_result
*id SERIAL INT, PKEY
result_metadata INT, NOT NULL
FKEY to t_result_metadata
point DOUBLE, NOT NULL
var DOUBLE, NOT NULL
time TIMESTAMP, NOT NULL
Estimates cont
analytical.t_total_estimate_conf
*id SERIAL INT, PKEY
estimation_cell INT, NOT NULL,
FKEY to c_estimation_cell
estimate_date_begin DATE, NOT NULL
estimate_date_end DATE, NOT NULL
total_estimate_conf VARCHAR(120), NULL
antcal.t_panel2total_1p_estimate_da
*id SERIAL INT, PKEY
total_estimate_data INT, NOT NULL,
FKEY to t_total_estimate_data
panel INT, NOT NULL,
FKEY to t_panel
reference_year_set INT, NOT NULL
FKEY to t_reference_year_set
antcal.t_panel2total_2p_estimate_da
*id SERIAL INT, PKEY
total_estimate_data INT, NOT NULL,
FKEY to t_total_estimate_data
panel INT, NOT NULL,
FKEY to t_panel
reference_year_set INT, NOT NULL

nFIESTA [the present]

- **Development of nFIESTA by ÚHÚL** since the DIABOLO end (2018);
- nFIESTA became the **evaluation tool of the Czech NFI**;
- nFIESTA is **managed on GitLab** following rules and standards of collaborative software development (issues, branches, merge requests, pipelines running regression tests etc.);
- **the 2nd nFIESTA workshop** took place between 10 and 16 June 2024
- selection of **Czech NFI and auxiliary data (Copernicus Forest Type Map 2018) made freely available** / demonstration purposes and testing (7 Hands-on sessions)

nFIESTA [the present]

- **Several new PostgreSQL extensions**
  - nfiesta_sdesign – to hold and manage information about the inventory design (sampling design, temporal aspects, plots, clusters etc.);
  - nfiesta_gisdata – to specify estimation domains (cells) and associate plots to these cells, to determine values of auxiliaries at exact plot locations and to derive totals of auxiliaries within estimation cells;
  - nfiesta_target_data – to aggregate survey data at single plot level, eventually by various categories of territory (e.g. land tenure) or subpopulation (e.g. species or regeneration height class);
- **and four GUI modules**
  - **ESTIMATES** – front end to extension nfiesta (configuration and calculation of estimates);
  - **FIELD DATA** – front-end to nfiesta_tartget_data (preparation of plot values from source data);
  - **GIS DATA** – front end to nfiesta_gisdata (preprocessing of auxiliaries – GIS maps);
  - **GIS DATA** – front end to nfiesta_gisdata (preprocessing of auxiliaries – GIS maps);

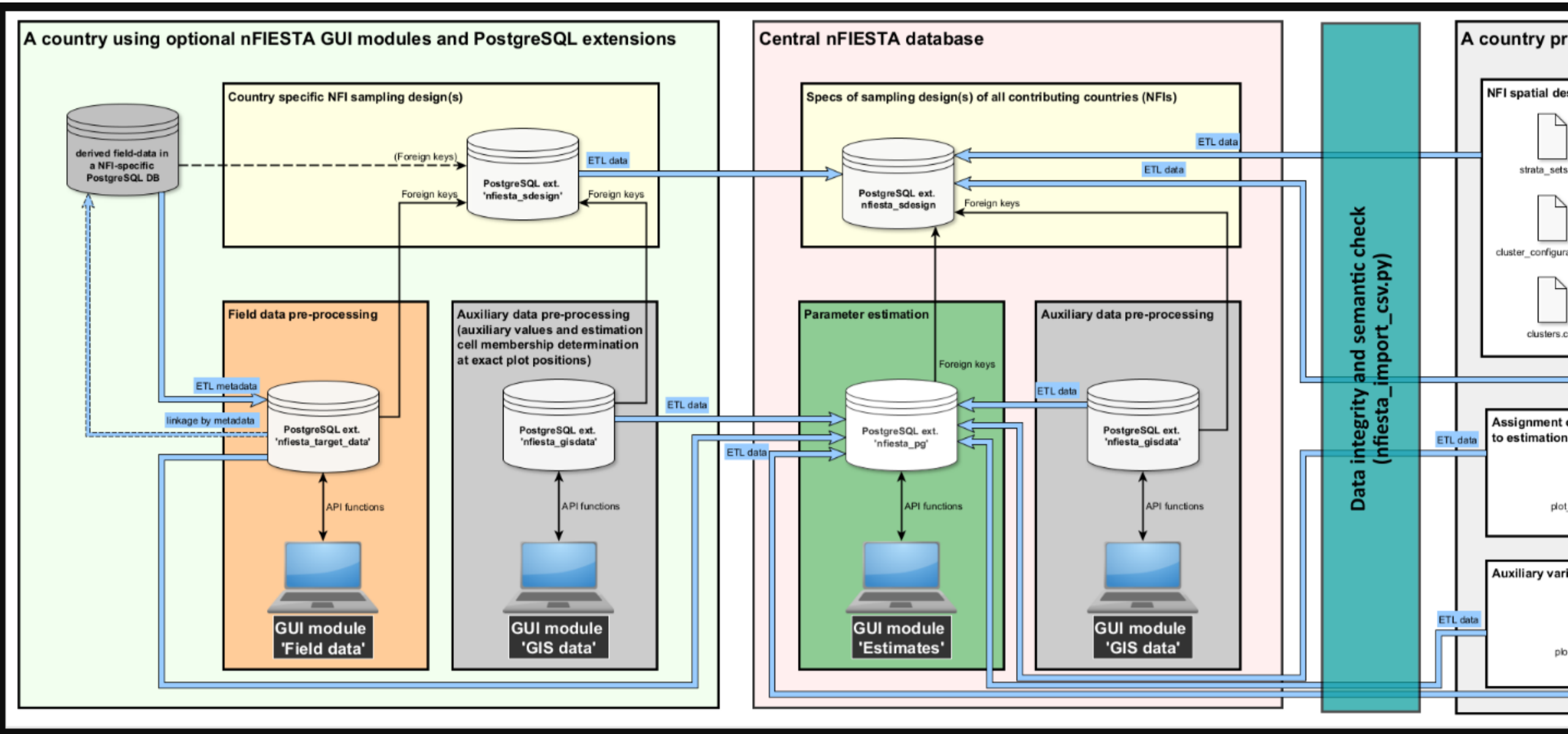
nFIESTA [the present]

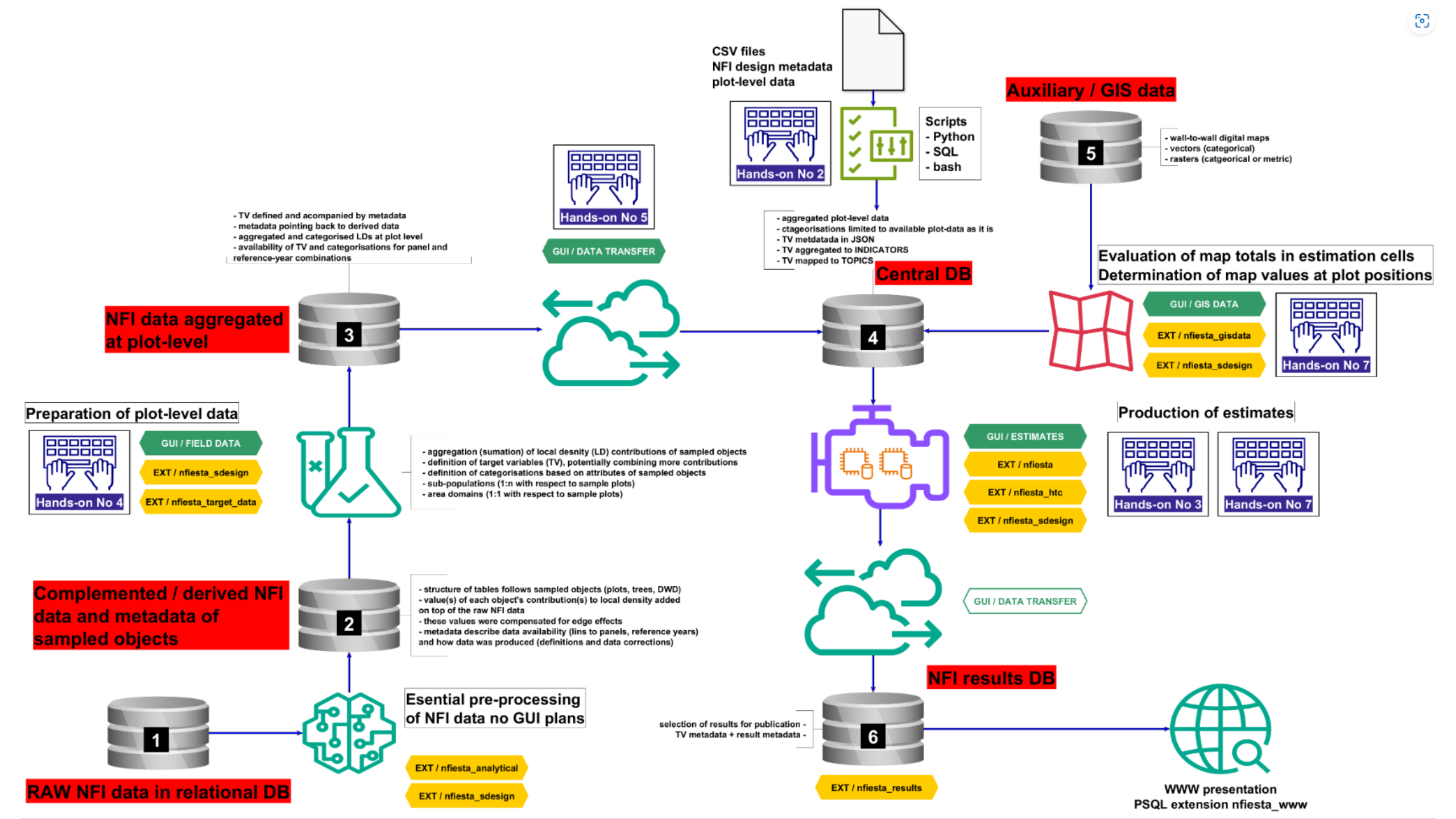
PathFinder (Towards an Integrated Consistent European LULUCF Monitoring and Policy Pathway Assessment Framework), Horizon Europe (HORIZON-CL5-2021-D1-01)

- **Task 2.1: Developing a mapping and estimation platform** (Month 3 – 24, VTT, UHUL, LUKE, TM)
- **Task 2.3: Statistically-sound estimators for combining field and remotely sensed data** (Month 12 – 36, UHUL, VTT, LUKE, IGN, TI, CISIC, NIBIO, UGOE, TM)
- **Task 2.3: Demonstration of the mapping and estimation platform** (Month 24 – 42, VTT, UHUL, LUKE, TM, JRC)

The present-day architecture of nFIESTA

PostgreSQL extensions, databases and GUI modules




CSV files
NFI design metadata
plot-level data
Hands-on No 2
Scripts
- Python
- SQL
- bash
Auxiliary / GIS data
5
- wall-to-wall digital maps
- vectors (categorical)
- rasters (catgeorical or metric)
- aggregated plot-level data
- ctageorisations limited to available plot-data as it is
- TV metdatada in JSON
- TV aggregated to INDICATORS
- TV mapped to TOPICS
Central DB
Evaluation of map totals in estimation cells
Determination of map values at plot positions
GUI / GIS DATA
EXT / nfiesta_gisdata
EXT / nfiesta_sdesign
Hands-on No 7
- TV defined and acompanied by metadata
- metadata pointing back to derived data
- aggregated and categorised LDs at plot level
- availability of TV and categorisations for panel and reference-year combinations
Hands-on No 5
GUI / DATA TRANSFER
NFI data aggregated at plot-level
3
4
Preparation of plot-level data
Hands-on No 4
GUI / FIELD DATA
EXT / nfiesta_sdesign
EXT / nfiesta_target_data
- aggregation (sumation) of local desnity (LD) contributions of sampled objects
- definition of target variables (TV), potentially combining more contributions
- definition of categorisations based on attributes of sampled objects
- sub-populations (1:n with respect to sample plots)
- area domains (1:1 with respect to sample plots)
Production of estimates
GUI / ESTIMATES
EXT / nfiesta
EXT / nfiesta_htc
EXT / nfiesta_sdesign
Hands-on No 3
Hands-on No 7
Complemented / derived NFI data and metadata of sampled objects
2
- structure of tables follows sampled objects (plots, trees, DWD)
- value(s) of each object's contribution(s) to local density added on top of the raw NFI data
- these values were compensated for edge effects
- metadata describe data availability (lins to panels, reference years) and how data was produced (definitions and data corrections)
GUI / DATA TRANSFER
NFI results DB
1
Esential pre-processing of NFI data no GUI plans
selection of results for publication -
TV metadata + result metadata -
6
RAW NFI data in relational DB
EXT / nfiesta_analytical
EXT / nfiesta_sdesign
EXT / nfiesta_results
WWW presentation
PSQL extension nfiesta_www

Database

Indicator:

(121/18) volume of all dead wood forms, D(BH) >= 7 cm o. b. / stand area and clearcuts [m3 o.b. / ha]

	numerator		denominator
state or change	state variable	state or change	state variable
local density contribution	lying merchantable deadwood ≥ 1	local density contribution	stand area (plot centre)
version	no backward correction + no	version	no backward correction
definition variant	null + ČSOT; stump approximated	definition variant	productive forest area according to centre
area domain	accessible part; forest +	area domain	accessible part; forest
population	length ≥ 1 m + stumps and dead	population	null
area domain	altogether	area domain	altogether
subpopulation	altogether	subpopulation	altogether

Columns selection | Estimate configuration | Estimate calculation | Export data | Display history | Display panels | Estimation periods | Panel groups | Cell collections | Estimate type (phase) | Cancel rows selection

Estimates:

Period	Group of panels	Estimate status	Geographical division	Estimation cell	Numerator category	Point estimate	Standard error	Minimal sample size	Actual sample size	Confidence interval	Phase estimate	Estimate is additive	Latest estimate version	Calculation started	User who configurated estimate
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ041 - Karlovarský	standing dead stem or torso	4,7117675	0,5127412	29889	39407	1,0049852	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ042 - Ústecký	standing dead stem or torso	7,9155071	0,9724274	107202	39407	NULL	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ051 - Liberecký	standing dead stem or torso	6,6447647	1,0073171	212235	39407	NULL	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ052 - Královéhradecký	standing dead stem or torso	5,7736196	0,6371548	50265	39407	NULL	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ053 - Pardubický	standing dead stem or torso	6,8216066	0,9595276	84276	39407	NULL	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ063 - Vysočina	standing dead stem or torso	13,0280104	1,8245063	51100	39407	NULL	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ064 - Jihomoravský	standing dead stem or torso	12,1767492	1,4173972	48898	39407	NULL	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ071 - Olomoucký	standing dead stem or torso	6,9623687	0,7517192	37603	39407	1,4733878	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ072 - Zlínský	standing dead stem or torso	6,4689861	0,7175490	62389	39407	NULL	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ080 - Moravskoslezský	standing dead stem or torso	8,0112141	0,7552749	25636	39407	1,4803570	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS1	CZ0 - Czech Republic	stump	4,2899257	0,0493624	412	39407	0,0967515	single-phase	☑	☑	2024-06-24 22:00...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS2	CZ01 - Prague	stump	1,5150820	0,3506115	64572	39407	NULL	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS2	CZ02 - Central Bohemia	stump	3,7482395	0,1328907	4152	39407	0,2604690	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS2	CZ03 - Southwest	stump	4,3883338	0,0975376	1695	39407	0,1911761	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS2	CZ04 - Northwest	stump	3,5034948	0,1158905	3766	39407	0,2271483	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS2	CZ05 - Northeast	stump	3,8892268	0,1141608	2536	39407	0,2237580	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS2	CZ06 - Southeast	stump	4,7476974	0,1435304	2839	39407	0,2813231	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS2	CZ07 - Central Moravia	stump	4,8254480	0,1546719	2655	39407	0,3031607	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS2	CZ08 - Moravia-Silesia	stump	5,2704699	0,1981554	2996	39407	0,3883893	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ010 - Prague, the capital	stump	1,5150820	0,3506115	64572	39407	NULL	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt
2016-2020 (CZ-NFI3)	CZ-NFI3-s2 (2016-2020)	estimate was calculated	NUTS3	CZ020 - Středočeský	stump	3,7482395	0,1328907	4152	39407	0,2604690	single-phase	☑	☑	2024-06-24 21:59...	KMAdolt

(estimation_period_label_en IN ('2016-2020 (CZ-NFI3)')) AND (numerator_variable_label_en IN ('lying, dead, merchantable wood', 'standing dead stem or torso', 'stump'))

69 estimates are selected.

Previous

Database

Selection of the target variable

Selected local density object group: **(4) merchantable wood stems and regeneration stems**

Selected target variable: **(21) above ground biomass**

Target variable:

100 - state variable

- 21 - above ground biomass
- 24 - above ground biomass
- 25 - harmonized volume o. b.
- 26 - harmonized volume o. b.
- 53 - above ground biomass
- 54 - above ground biomass
- 59 - harmonized volume o. b.
- 60 - harmonized volume o. b.
- 76 - carbon
- 77 - carbon
- 78 - carbon
- 79 - carbon

Local density:

- 52 - AGB of merchantable wood stems (positive contribution)
- 53 - AGB of non-merchantable stems (positive contribution)

Unit of measure:

ID	Label	Description
1000	t	Tonne.

Definition variant:

ID	Label	Description
17	AGB by allometric equations.	Above ground biomass calculated based on the allometric equations for 4 main economical species: Picea Abies (VULHM, 2016), Pinus Sylvestris (Ciencala et al., 2

Area domain category:

ID	Label	Description	Local density object label	User defined
6	forest	Land category forest according to FAO FRA.	inventarization circle	☐
201	accessible part	Accessible part	centre of the IP (field data)	☐
201	accessible part	Accessible part	inventarization circle	☐
35416	forest and OWL	Land category according to FAO FRA forest and Other Wooded Land.	centre of the IP (field data)	☐

Subpopulation category:

ID	Label	Description	Local density object label	User defined
29101	living merchantable wood stems	Living merchantable wood stems, including living windfalls, without stumps and standing dead stems.	merchantable wood stems (DBH >= 7 cm)	☐

Version:

ID	Label	Description
100	no backward correction	No correction of inventory data based on the following survey.

Previous | Next

nFIESTA [the near future]

MoniFun (Co-creating a blueprint of a harmonised European Forest Multifunctionality Monitoring System), Horizon Europe (HORIZON-CL6-2023-CIRCBIO-01)

- **T4.2: Assess setup, performance & feasibility of domain-level estimations,** Task Leader: TI, M03-M30
- **T4.4: Synthesise conclusions relevant for the design of EFMMS,** Task Leader: ÚHÚL, M03-M45
- **T1.2: Design EFMMS, an interoperable information system for monitoring the multifunctionality of forests,** Task Leader: ÚHÚL, M13-M48

nFIESTA [the near future]

- Implementation of **two-phase estimators** derived from Horvitz-Thompson theorem for infinite populations.
- Widening the range of **use-cases supported by GUI**.
- Improvement of **computational performance**.
- **EU Forest monitoring** (law) implementation**?**

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Thank you for your attention!

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