MAPPING THE DIEBACK OF SEVERAL TREE SPECIES IN CENTRE OF FRANCE USING SENTINEL-2 DERIVED INDICES - A CASE STUDY IN CENTRE-VAL DE LOIRE REGION OF FRANCE FOR OAK TREES

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1. RECONFORT project : context, material and method

1.1. Context and objectives

- Forest dieback is associated to successive droughts and heatwaves in recent years.
- This trend is expected to increase in the future.
- Widespread weakening of stands of several important tree species is already being observed in the forests of the Centre-Val de Loire region [1]

Objective: Develop approaches and tools to better assess forest dieback

1.2. Reference data

Trees are categorized using the DEPERIS method [2] (grade from A to F). A plot is considered declining if the percentage of trees with a grade higher or equal to D is higher than 20%.
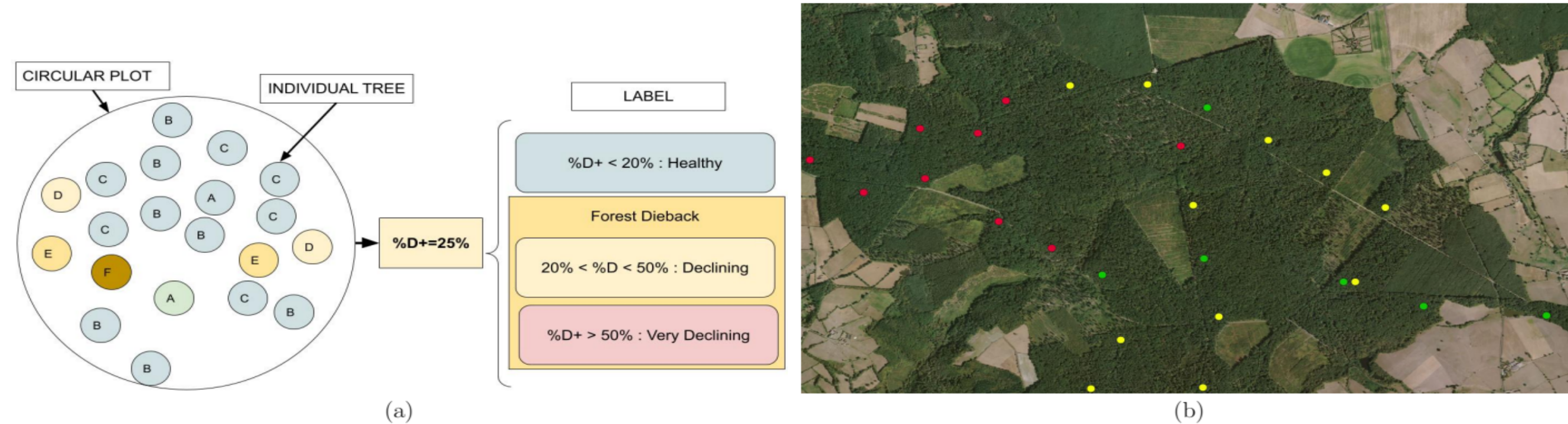

Figure 1: Example of a ground-truth plots in the Tronçais forest (green/yellow/red colors correspond to healthy/declining/very declining plots).

→ around 2,700 labeled oak plots in the Centre-Val de Loire region (11 Sentinel-2 tiles).
→ Extended to chestnut and pine

1.3. Spectro-temporal analysis

The CRswir index combines the spectral bands of the Short-Wave Infrared (SWIR) regionand is correlated with the water content of the canopy. A similar index (CRre) is used, focusing on the red edge of the spectrum, which is correlated to the chlorophyll content of the canopy.
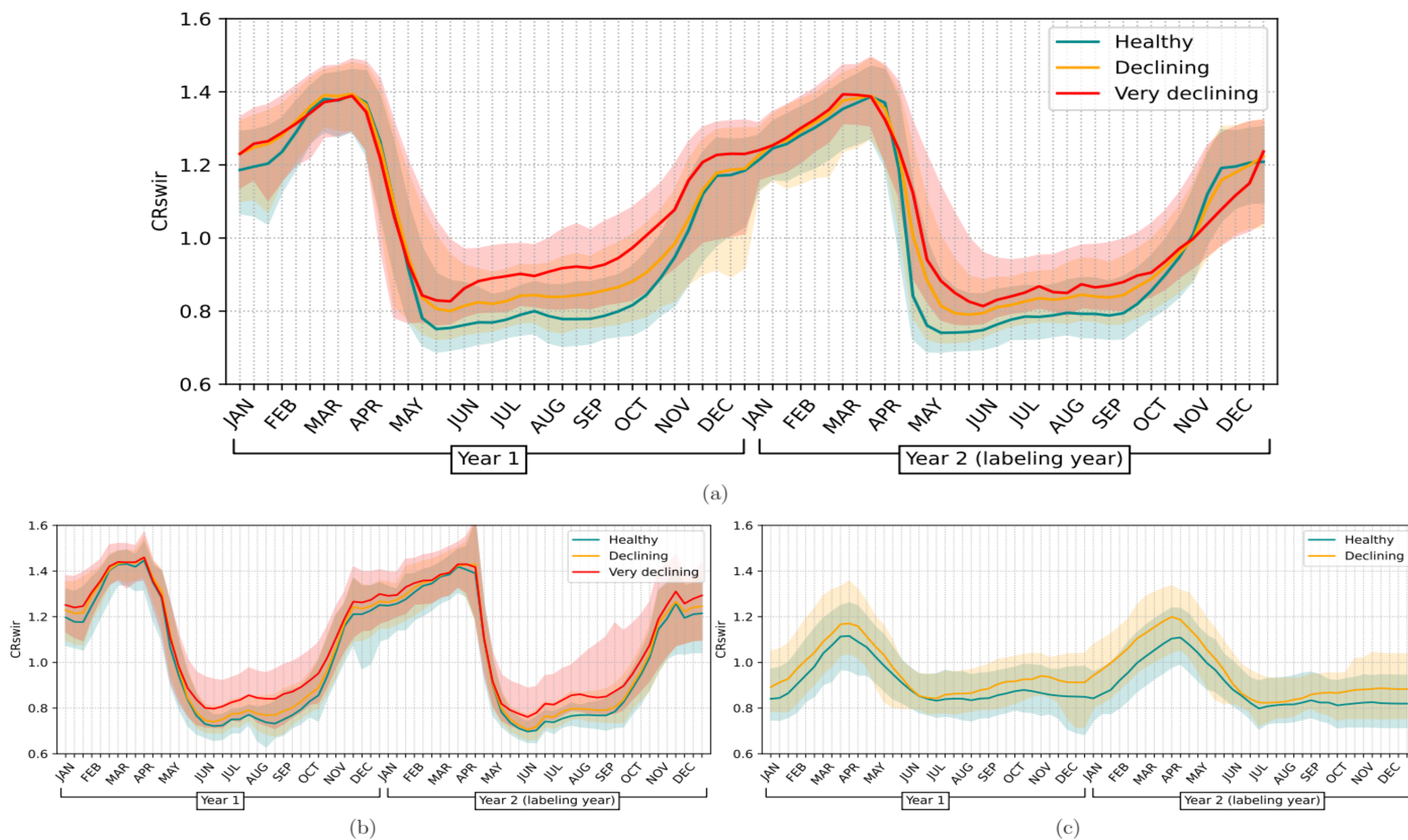

Figure 2: Median and inter-quartile range of CRswir time series according to their health category for (a) oak, (b) chesntu and (c) pine. Green/yellow/red colors correspond to healthy/declining/very declining plots.

1.4. A multi-annual classification model for predicting forest dieback using Sentinel-2 time series
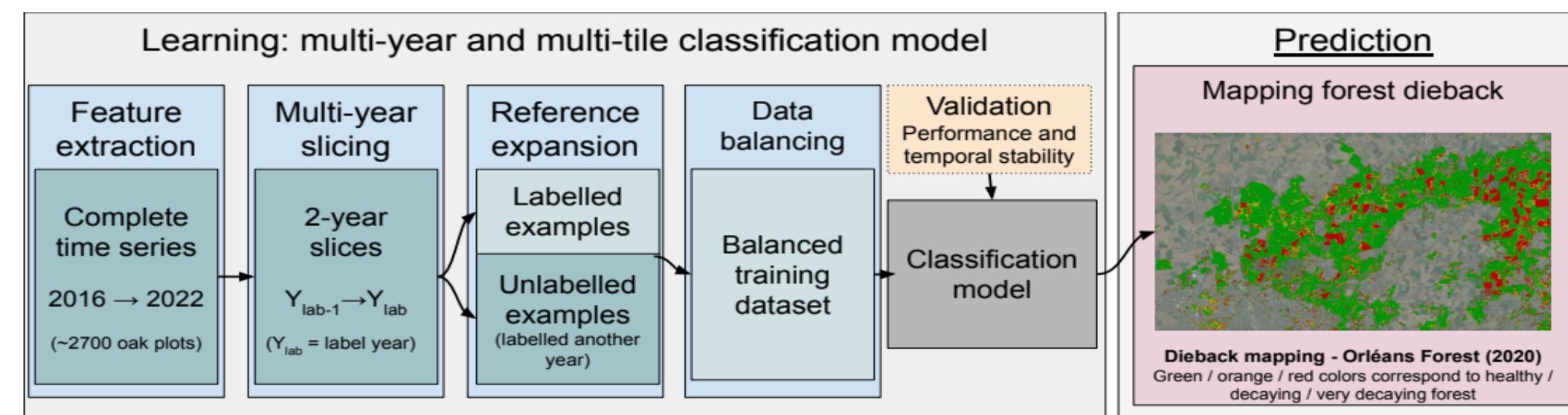

Figure 3: Processing chain used to train a classification model for forest dieback detection.

Data Expansion: unlabeled time series slices are added to the training database. Healthy plot labeled year Y_{lab} are assumed to have been healthy years $Y_{lab} - 1$ and $Y_{lab} - 2$. Declining plots in year Y_{lab} are assumed to have continued to decline in years $Y_{lab} + 1$ and $Y_{lab} + 2$.
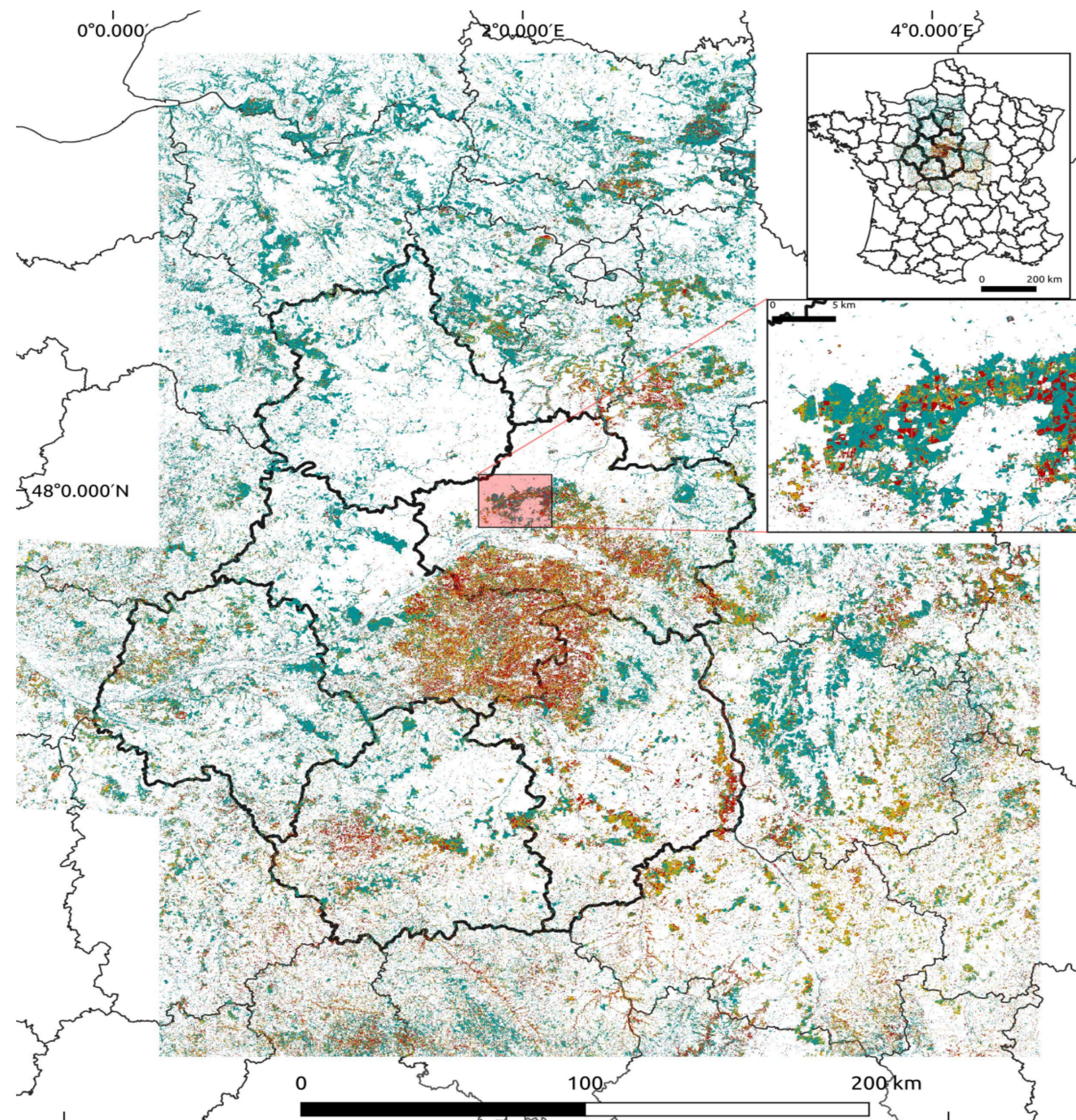
2. Results [3]

Figure 4: Final map production for the year 2022. Healthy, declining and very declining pixels are in cyan, orange and red, respectively. The deciduous tree OSO land cover map is used.

Table 1: Classification results obtained for chestnut (ches.), pine and oak trees for each year and overall (mean over each year). In parentheses, the 95% confidence interval.

Spec.	Year	OA (2c.)	BA (2c.)	OA (3c.)	BA (3c.)
Ches.	All	77 (0.7)	73 (0.9)	63 (0.7)	60 (0.9)
Ches.	2020	76 (0.6)	73 (2)	64 (2)	59 (2)
Ches.	2022	78 (1)	74 (2)	61 (2)	61 (2)
Pine	All	80 (1.8)	73 (2)	-	-
Pine	2020	84 (1.7)	68 (4)	-	-
Pine	2021	85 (6)	85 (6)	-	-
Pine	2023	72 (2)	66 (2)	-	-
Oak	All	79%	78%	65%	61%

Evaluated factor	Result
Mapping accuracy	Overall Acuracy ~ 80%
Most important features	CRswir and CRre (in summer)
Time period used for the detection	2 years
Classification algorithm	Random Forest
Temporal stability	Improved using data balancing and data expansion
Predict new years	Drop in accuracy ~5%
Predict areas without any groundtruth	Drop in accuracy ~4%

References

[1] DSF, Lettre du DSF : situation sanitaire des forêts à mi-année, Département de la Santé des Forêts, 2020.
[2] M. Goudet et al. Quantifier l'état de santé de la forêt, méthode simplifiée d'évaluation. *Note de service, DGAL/SDQSPV*, 2018.
[3] Mouret, F., Morin, D., Martin, H., Planells, M., Vincent-Barbaroux, C. (2023). Toward an operational monitoring of oak dieback with multispectral satellite time series: a case study in Centre-Val de Loire region of France. (Preprint hal-04073294)