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RestorEO: Towards an EO-based monitoring system for biodiversity and ecosystem restoration in Austria

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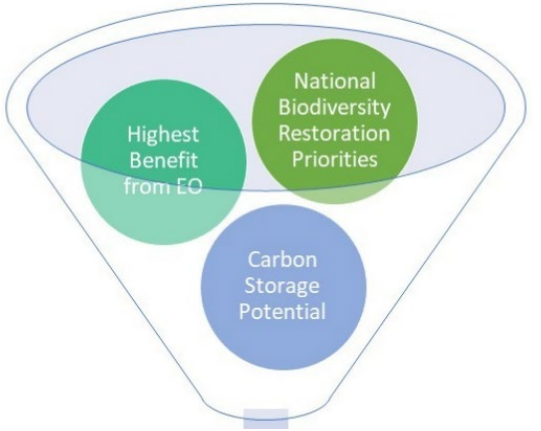
The RestorEO project

- RestorEO is a research project funded via Austrian Space Applications Program
- Focus on Austrian national biodiversity and restoration reporting duties
  - **National Restoration Plan** (Paternoster et al. 2021)
- **Project goals:**
  - Develop EO proxies to support national biodiversity & ecosystem restoration monitoring
  - Develop EO proxies to support national conservation activities
  - deliver wall-to-wall EO data products / proxies to support national restoration reporting duties (e.g. Environment Agency Austria)
- **Developments focus on habitats of three ecosystems:**
  1. forest ecosystems
  2. grassland dominated cultural landscapes
  3. wetlands



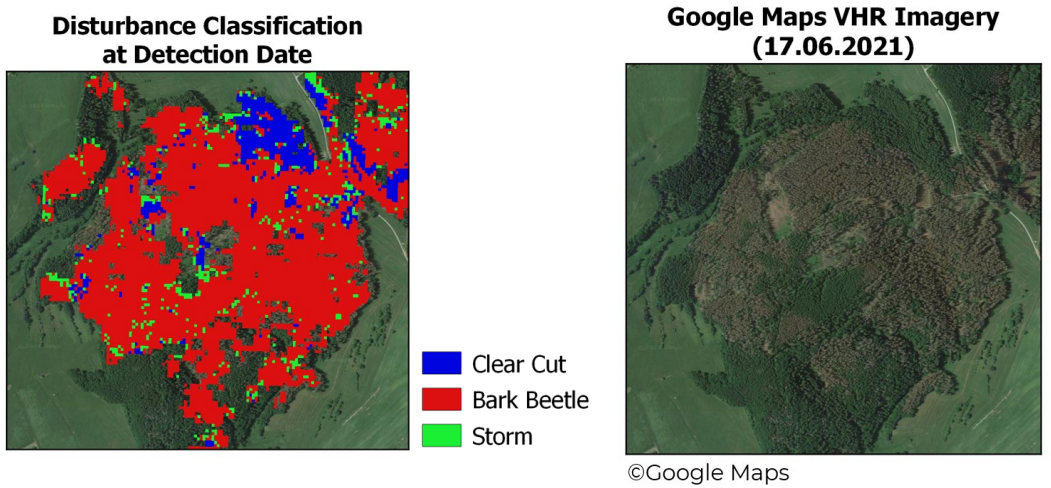
Forest ecosystems

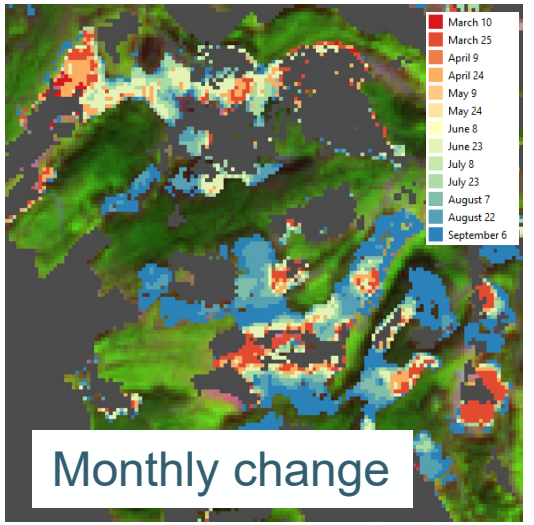
- A total of **18 habitat types for forests** are found in Austria.
- For these habitat types, we identified various indicators to describe conservation status.
- We evaluated if these indicators by their relevance and assessed suitable remote sensing techniques (report)
- **16 indicators were analyzed**. For **selected indicators** we developed and tested new EO products:
  - Forest disturbance data
  - Deadwood and coarse woody debris
  - Connectivity
  - Forest vertical structure

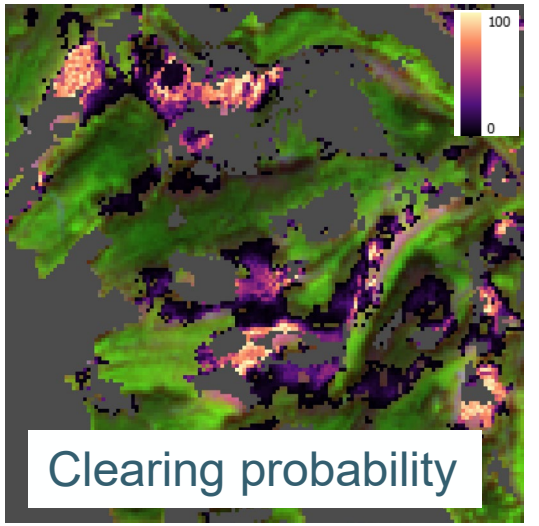
Indicator (english)	Frequency in 18 habitat types (number)	Frequency (relative in %)	Assessment of applicability with remote sensing
Tree species composition	17	94	Highly accurate classification on a local to regional level is possible; intra-deciduous differentiation more difficult; difference between deciduous and coniferous often sufficient and accurate
Indicator species	17	94	Not possible, especially, if under the canopy
Coarse woody debris, deadwood	17	94	Standing deadwood well depicted in orthophotos as well as in infrared; automated recognition is challenging
Forest use	16	89	Possible through timeseries analysis
Influence of game	13	72	Not measurable at typical level
Area size	12	67	Can be easily derived. Should be expanded with fragmentation analysis, which is not (yet) a defined indicator
Forest Structure	11	61	Can be analyzed with laser scan data (e.g., FHD value)

Forest ecosystems

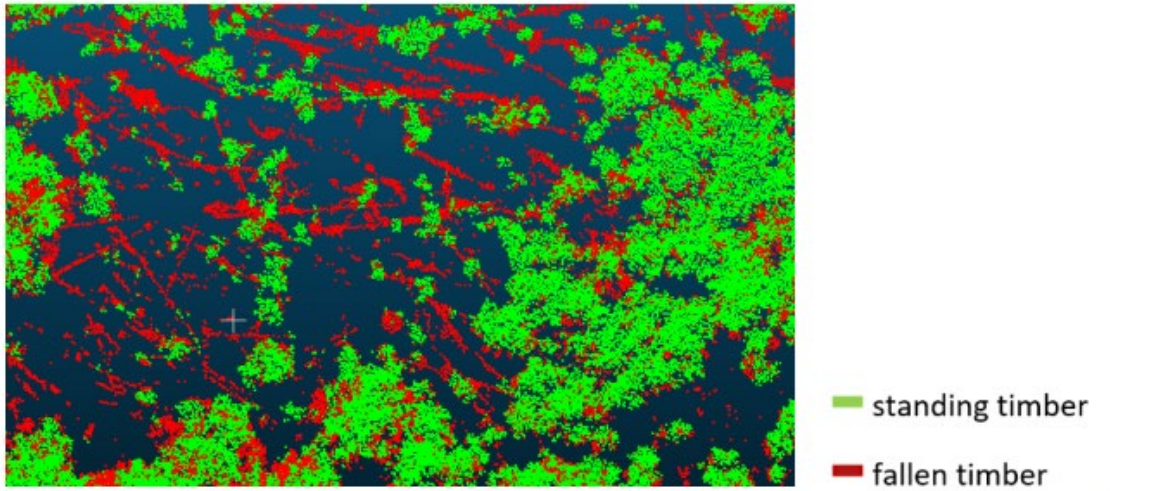
- **Disturbance mapping (monthly, agent info) and clearing probability with Sentinel-2**







- **Deadwood and coarse woody debris mapping with LiDAR (UAV) or aerial imagery**



Forest ecosystems

- **Forest Vertical Structure** from both ALS and GEDI
- **Foliage Height Diversity (FHD)** is a measure of vertical structural complexity

  $\mathbf{FHD} = -\sum_{i=1}^{s} \mathbf{P}_i \cdot log\, \mathbf{P}_i$ with $\mathbf{P}_i$ pulse in 1m vert. layer
- We investigated FHD potential for identifying restoration success or failure in forests
- Test site: Waldviertel, where bark beetle attacks have led to severe forest degradation in the past.

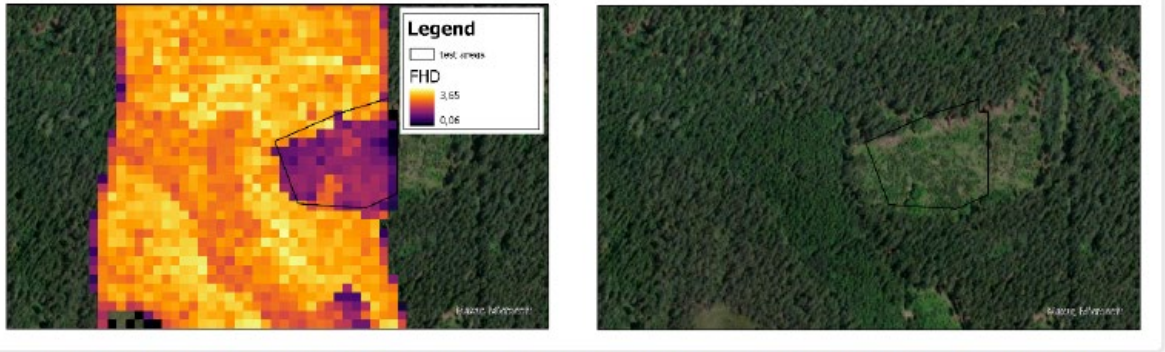


Abbildung 2.3.4: Analysis of FHD as an indicator for restoration after bark beetle attacks or clear cuts in Waldviertel

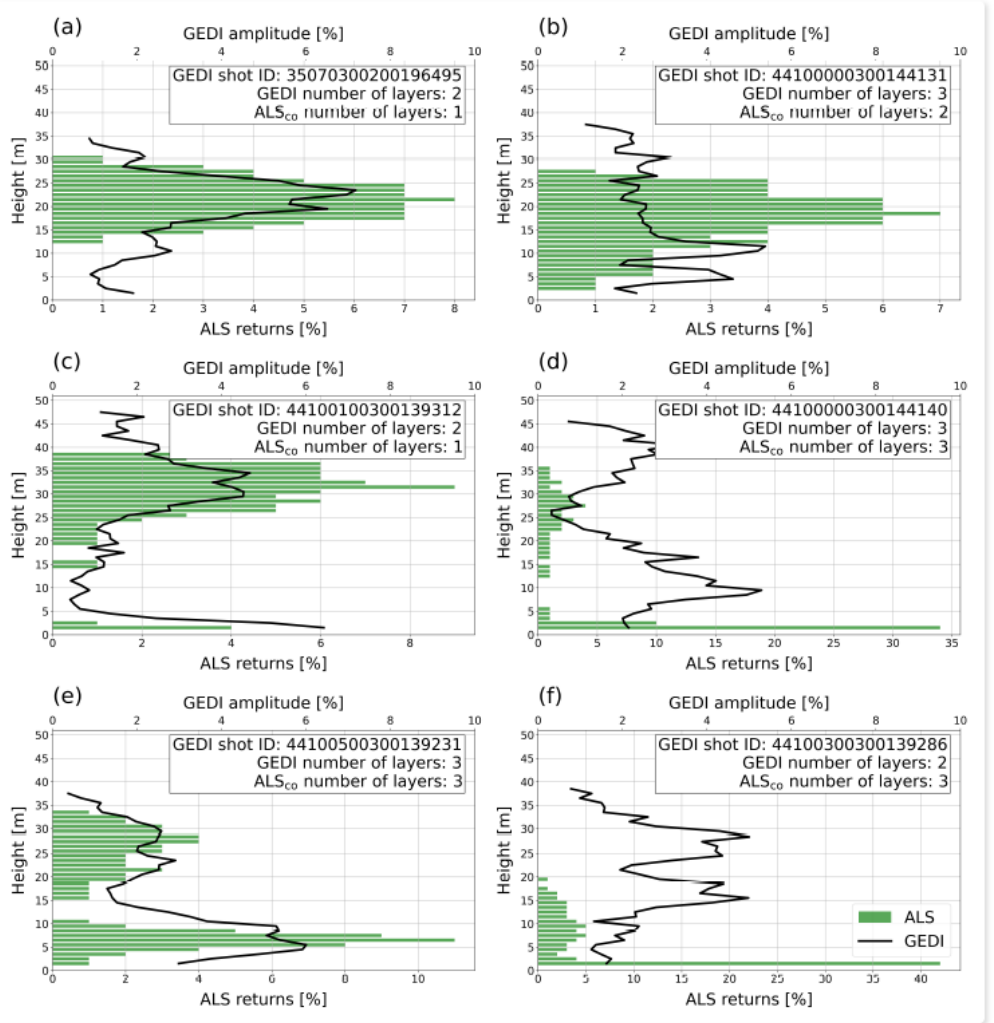
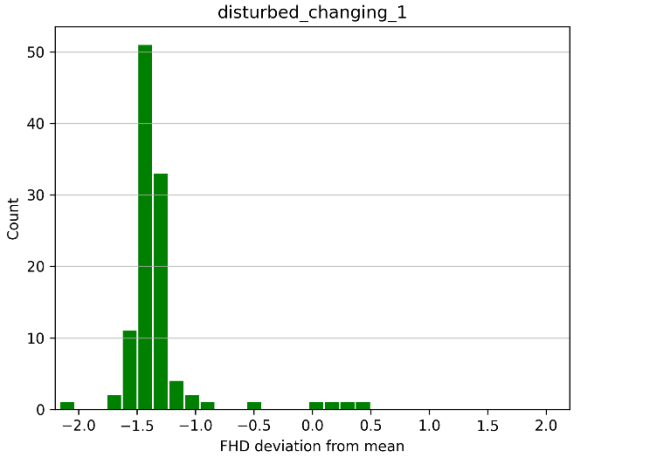
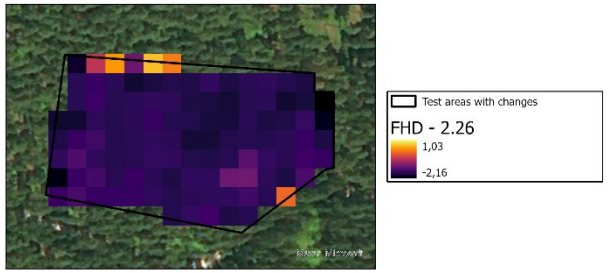


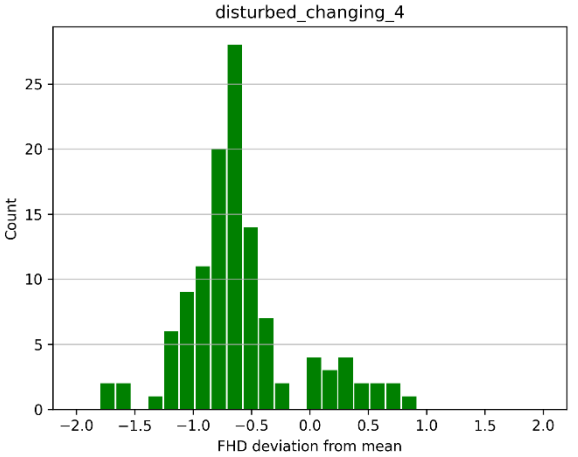
Abbildung 2.3.3: Different forest vertical structure profiles

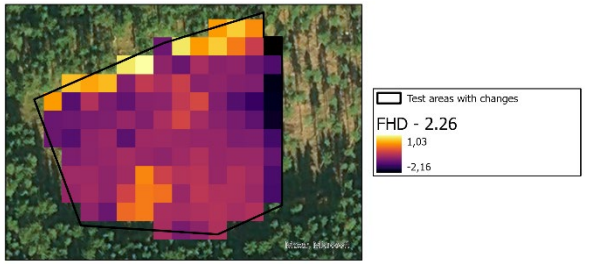
Forest ecosystems

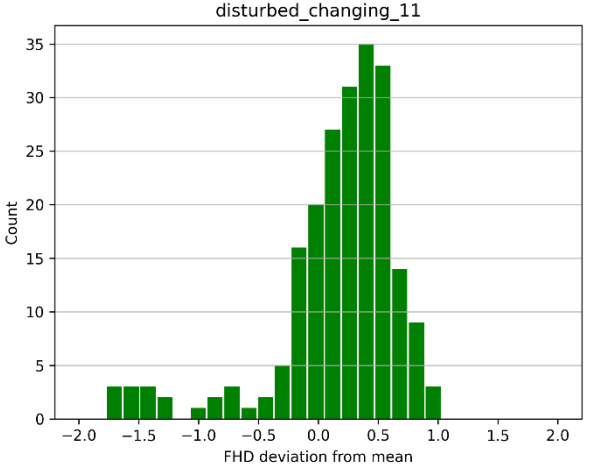
- Mean FHD is calculated for unchanged forest plots ($\mathbf{FHD_{mean}}$ = 2.26)
- $\mathrm{FHD_{mean}}$ is reference value for restoration status
- negative values represent areas where restoration is still ongoing -> related to forest regrowth

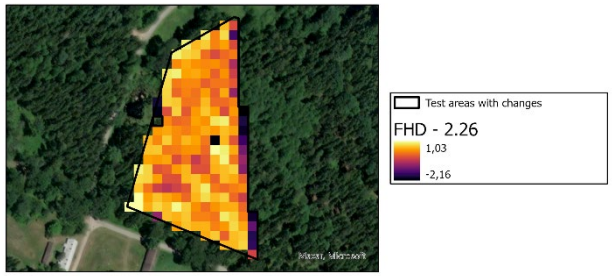






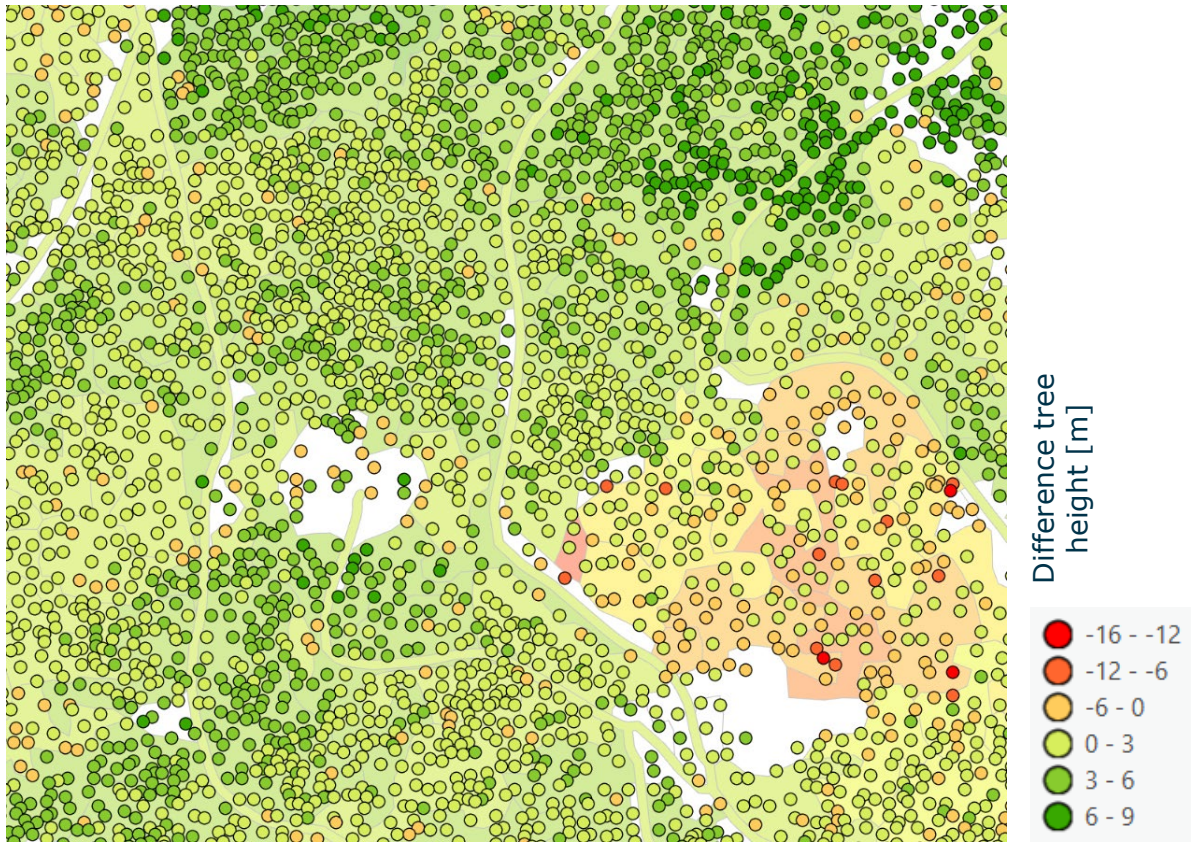


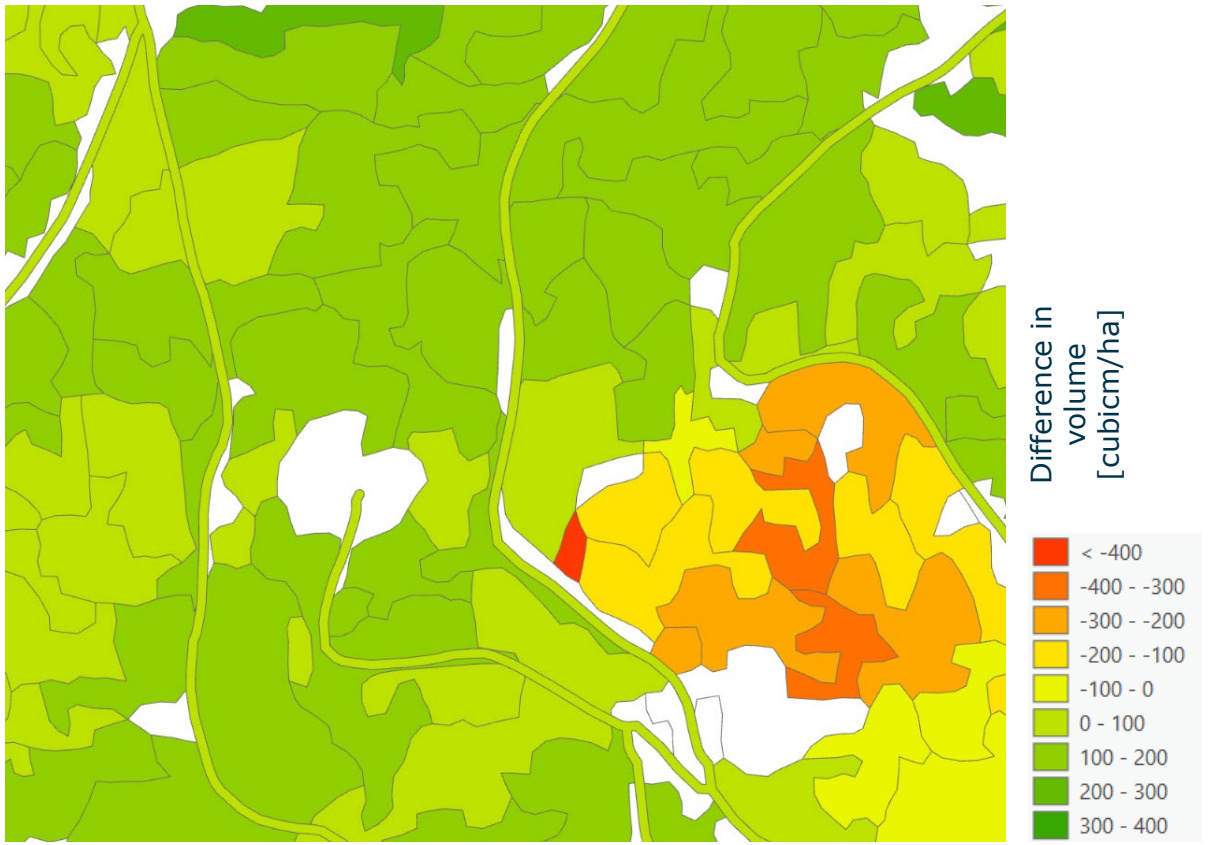




Forest ecosystems

- Single tree growth, timber volume and biomass change (ABG 2010-2022) from ALS data

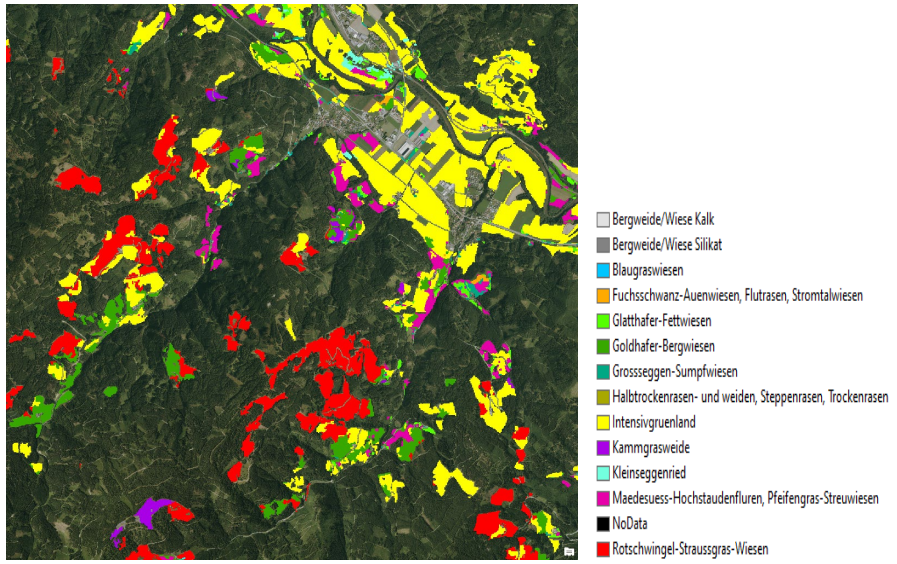


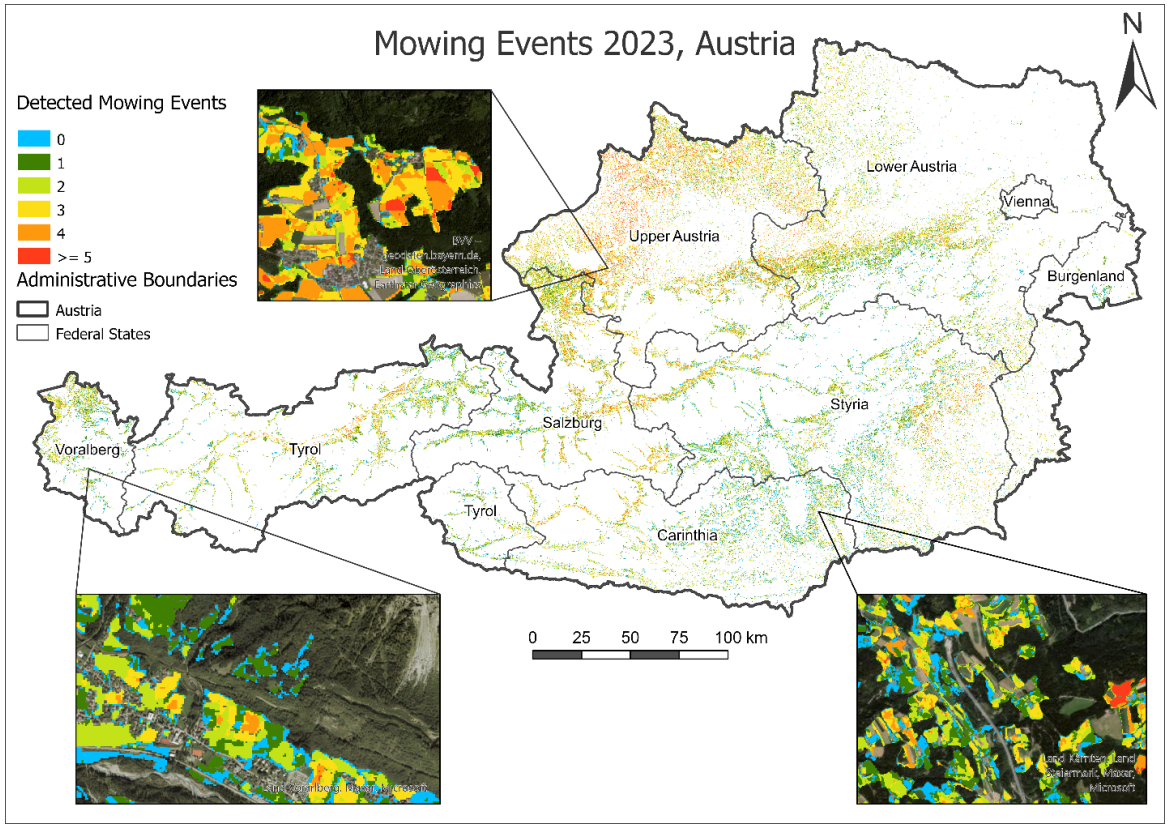


Grassland ecosystems

- We identified 8 relevant habitat indicators
- Focus on **mowing event detection** and **mowing intensity**, **meadow type classification**
- These proxies indirectly reflect plant species diversity and are used in butterfly habitat modeling
- Wall-to-wall annual assessment with **Sentinel-2**

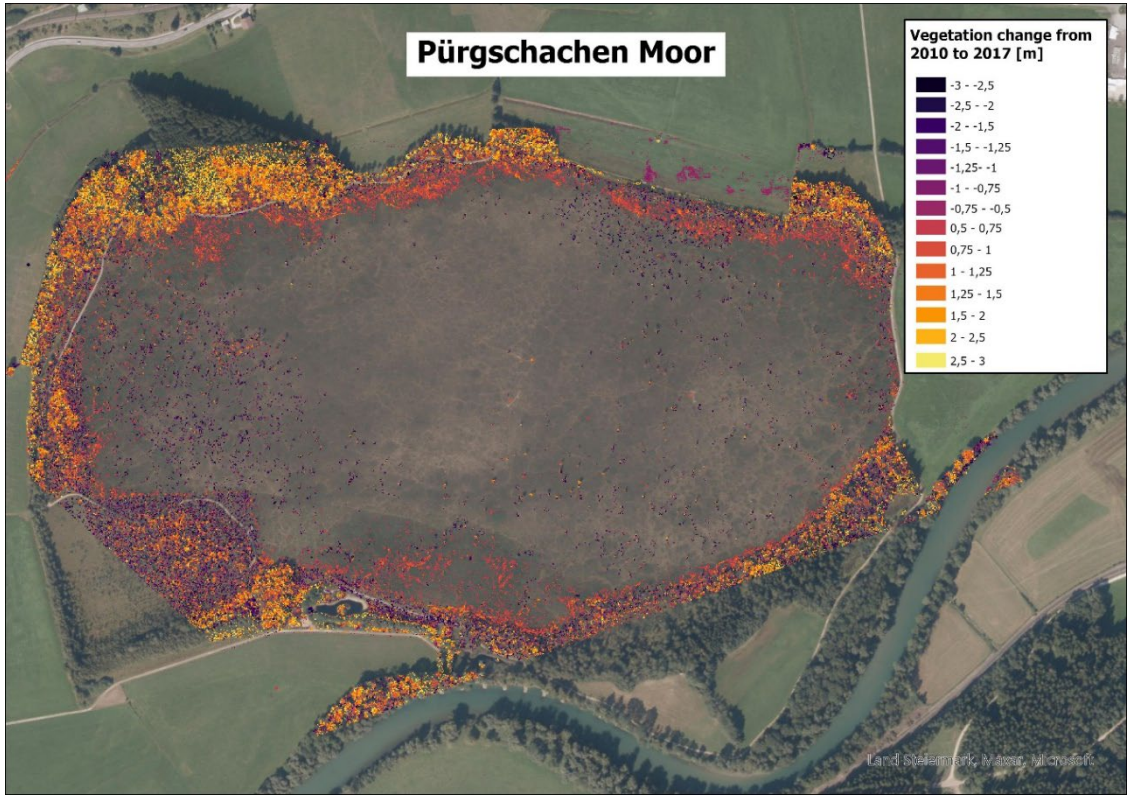
meadow type classification

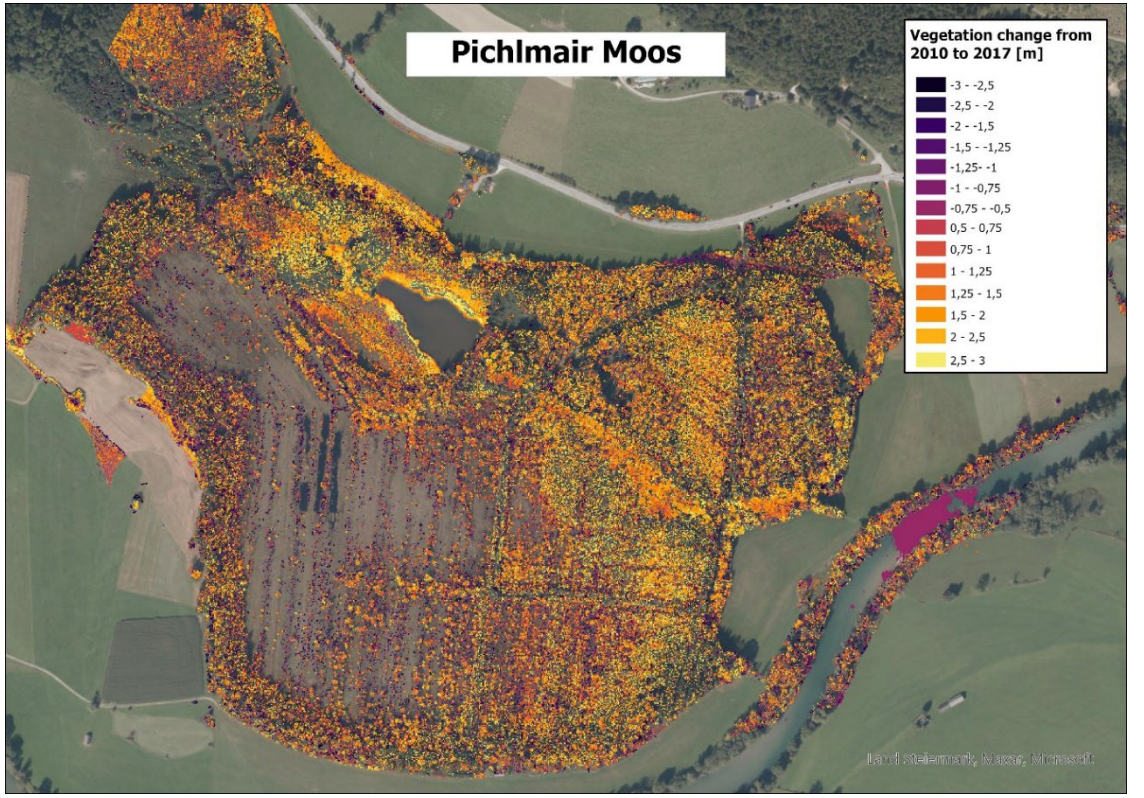




Wetland ecosystems

- We identified 17 relevant habitat indicators
- Focus on **shrub encroachment** and **drainage channel mapping** in Austrian moors and heathlands
- Data input: multitemporal ALS data –> available for 35% of Austria (status 01/2025)





Recommendations

- Workshop question: **What RS biodiversity products can support GBF targets**?
  - A highly ecosystem specific question -> there is not „one“ answer
  - Need for **VHR data** sets to account also for small landscape features
  - EO product accuracy
- **From an EO data scientists view: Why not learn from in-situ data sets?**
  - AI biodiversity database including in situ data, verified citizen science and EO data
  - Modeling and simulation knowhow
  - Collaboration of experts from biodiversity, biology, EO, data science, statistics (!), CS app developers, climatology…
  - We need modeling tools -> DestinE DT