

Extension of Version 4 of the Biogenic Emissions Landuse Database (BELD4) to Canada

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INTRODUCTION AND MOTIVATION

- Terrestrial vegetation is an important source of VOC emissions to the atmosphere, accounting for 80-90% of total global VOC emissions.
- Landuse data with detailed vegetation types at relatively high resolution are needed to accurately estimate biogenic VOC emissions.
- The Biogenic Emissions Landuse Database, Version 3 (BELD3), which contains 230 vegetation classes at 1-km resolution, was compiled for most of North America based on early 1990's satellite imagery (Pierce et al., 2000) and has been used widely for estimating biogenic emissions.
- Issues with BELD3 have been identified for Canada, such as less detailed crop species, large region of unknown tree species with zero emissions in eastern Canada, and discontinuities at the international and provincial borders for some species (Fig. 1).
- The U.S. EPA recently updated BELD from V3 to V4 with 286 landuse categories for the contiguous United States (<https://www.epa.gov/air-emissions-modeling/biogenic-emission-sources>). However, this new database only contains 17 broad landuse types based on MODIS satellite retrievals for Canada and Mexico (Fig. 2),
- A U.S.-equivalent of the BELD4 dataset has now been extended to Canada.

Limitations of EPA BELD4 for Canada and Mexico: Examples

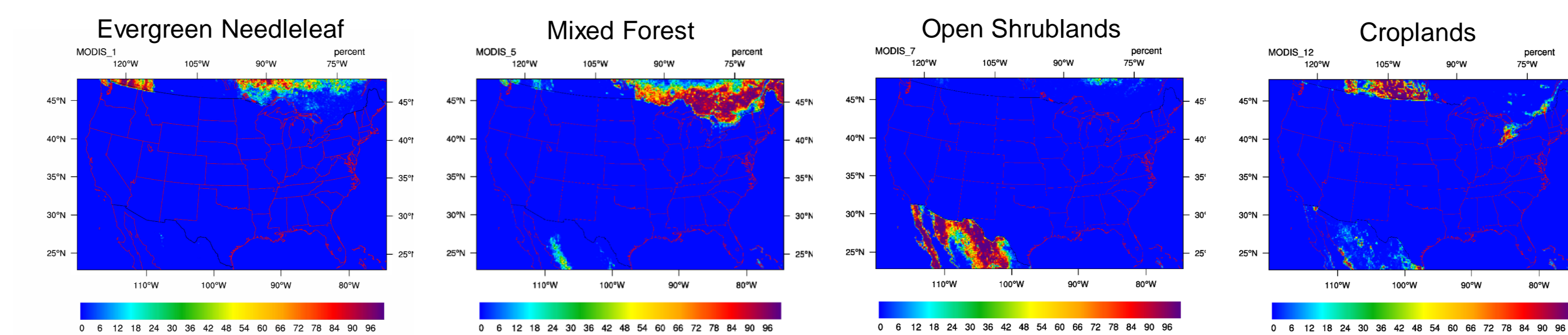


Figure 2. Examples of non-specific vegetation classes in the current EPA BELD4 database over the CMAQ CONUS 12km domain. Broad MODIS-based tree and crop classes are used for Canada and Mexico, which will result in incorrect biogenic emissions for Canadian and Mexican parts of the domain.

New Canadian + EPA BELD4: Examples

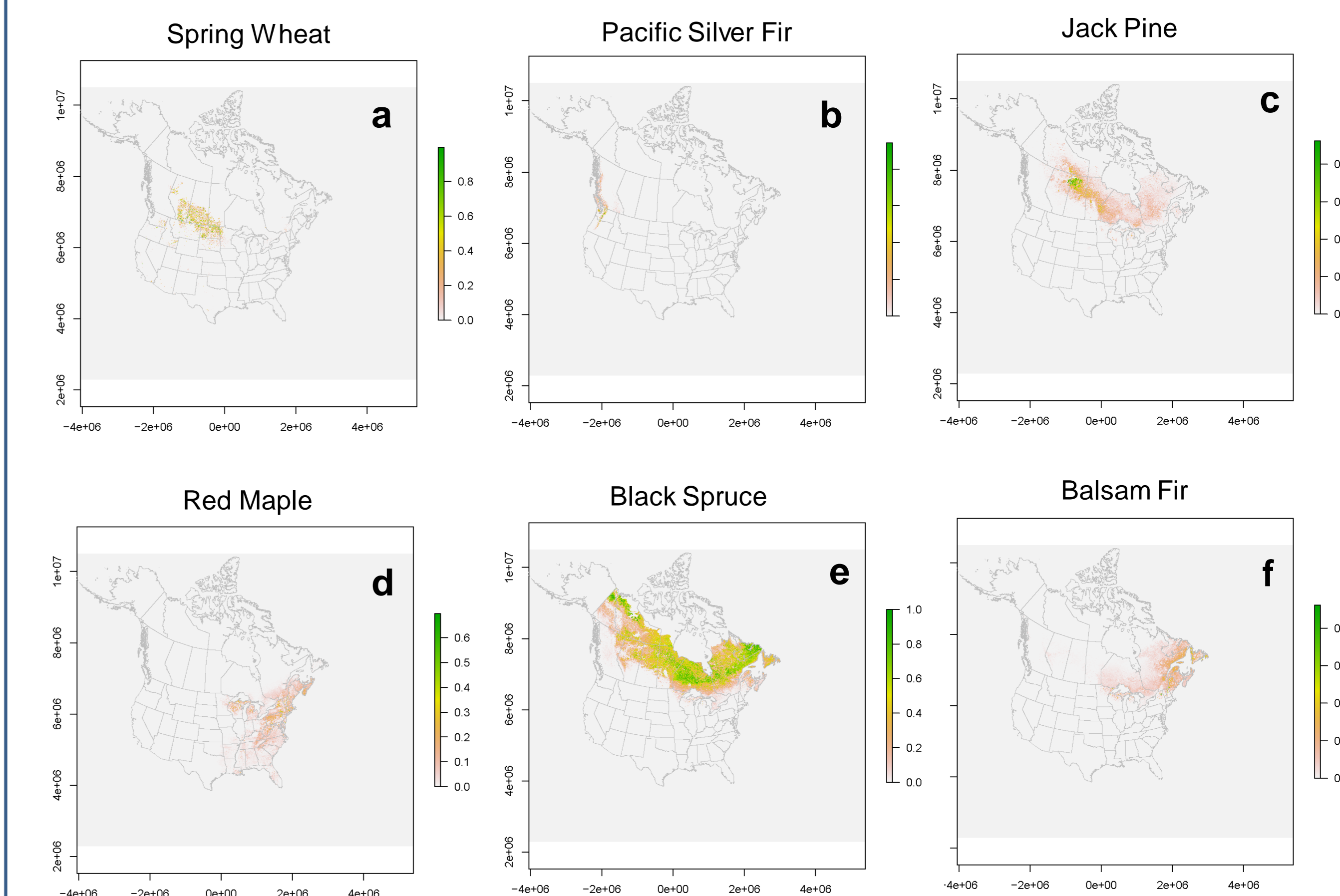


Figure 5. Examples of individual crop and tree species in the newly compiled BELD4 database with updated and improved Canadian landuse data: (i) detailed crop types match well with the EPA BELD4 data (Fig. 5a); (ii) discontinuities at international and provincial borders have largely disappeared and discontinuities within provinces are almost all entirely resolved (Figs. 5b, 5c, 5d, and 5e); (iii) significant improvement for spatial extent of Balsam Fir and Black Spruce, particularly for the province of British Columbia (Figs. 5e and 5f).

Issues with BELD3 for Canada: Examples

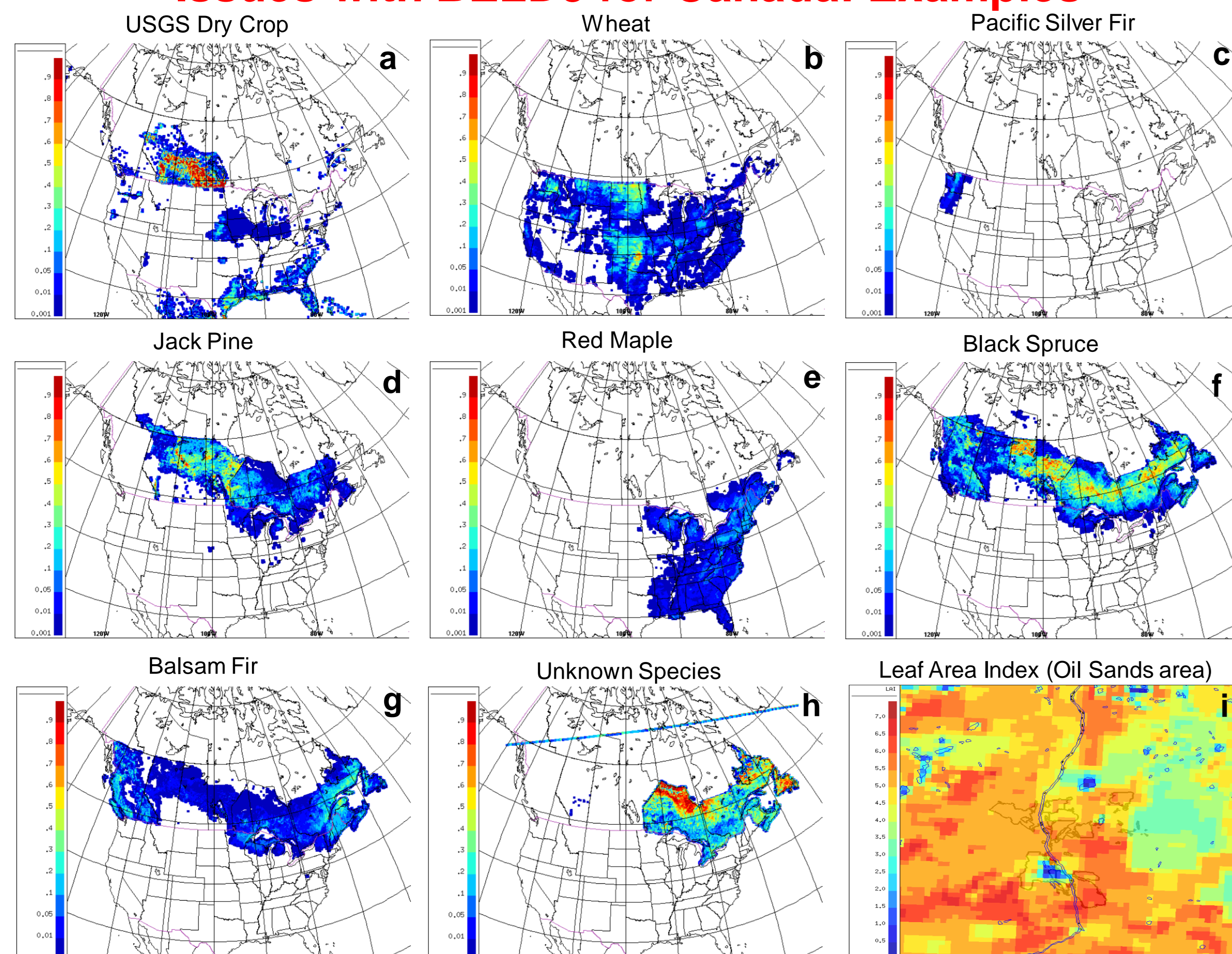


Figure 1. Examples of issues with the BELD3 data for Canada: (i) detailed crop types not available for some Canadian provinces (Panels 1a and 1b); (ii) discontinuities at international and provincial borders (Panels 1c, 1d, 1e, and 1f) and discontinuities within provinces (Panel 1f); (iii) unrealistic coverage of some tree species for some areas, such as Balsam Fir and Black Spruce for the province of British Columbia (Panels 1f and 1g); (iv) large fraction of unknown species in eastern Canada with zero emissions (Panel 1h); and (v) vegetation outdated for the Canadian Athabasca Oil Sands area (Panel 1i).

INPUT DATA SETS

➤ Canadian Annual Crop Inventory (ACI)

- Compiled by Agriculture and Agri-Food Canada (AAFC) (<http://www.agr.gc.ca/atlas/aci>); includes 71 codes/species, of which 66 are for crops
- Annual data available from 2013 to present for all provinces of Canada at 30m resolution; uses dominant species, does not cover entire country

➤ Canadian National Forest Inventory (NFI)

- Compiled collaboratively by federal, provincial and territorial government agencies (<https://nfi.nfis.org/en>)
- Canada-wide inventory was created using Nearest Neighbour (kNN) mapping method based on 2001 MODIS imagery at a resolution of 250m x 250m (Beaudoin et al., 2014); considers multiple species per grid cell, does not consider non-treed areas

METHODOLOGY AND RESULTS

- Original ACI data at 30m resolution were aggregated to 990m resolution and then resampled to 1km resolution to be consistent with the EPA BELD4 resolution
- Original NFI data at 250m resolution were aggregated to 1km resolution
- Sums of processed 1km resolution ACI and NFI data are larger than unity for some grid cells due to "double counting" of ACI and NFI databases (Fig. 3)
- Merged ACI and NFI data were finalized by renormalizing the grid cells with total fractional coverage larger than unity of summed ACI and NFI species (Fig. 4)
- Example plots of individual species fields are shown in Fig. 5

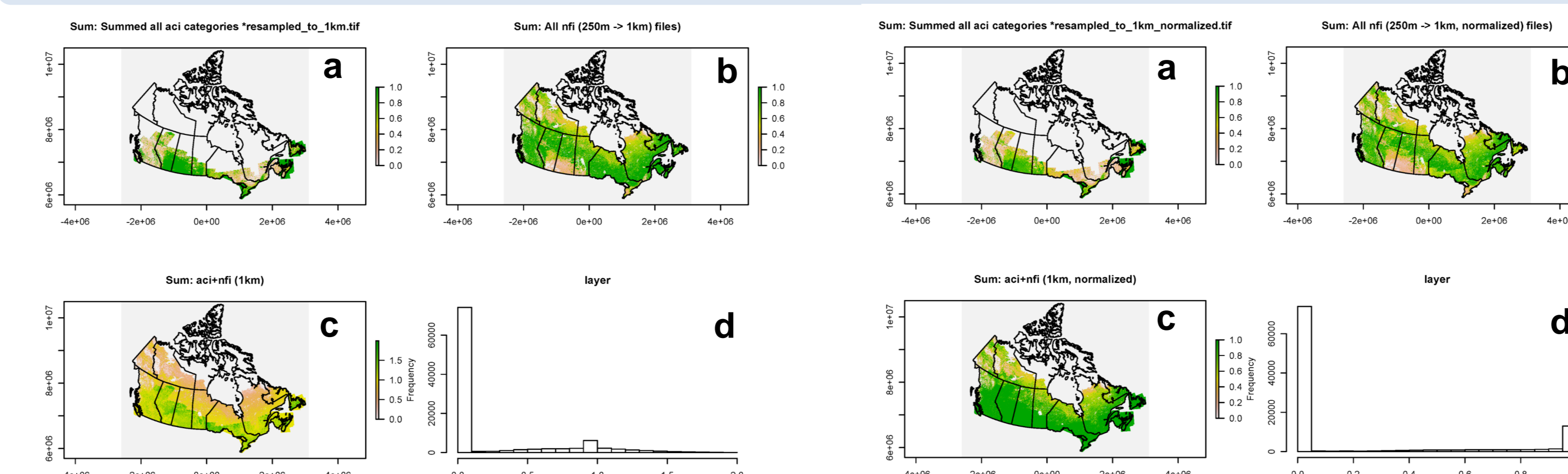


Figure 3. Sum of initial 1-km (a) ACI species, (b) NFI species, (c) total ACI and NFI species, and (d) histogram of the sum of ACI and NFI species.

Figure 4. The same as Fig. 3, but after normalization for grid cells with total fractional coverage of ACI+NFI species larger than unity.

SUMMARY

- U.S.-equivalent Canadian BELD4 database has been compiled based on the most recent Canadian crop and forest inventories
- Many existing issues with the BELD3 data for Canada were solved (Fig. 1 vs. Fig. 5)
- There are still areas for further improvement. For example, the 2001-MODIS-imagery-based Canadian national forest inventory is outdated for areas undergoing rapid development, such as the Canadian Athabasca Oil Sands area (Fig. 6)

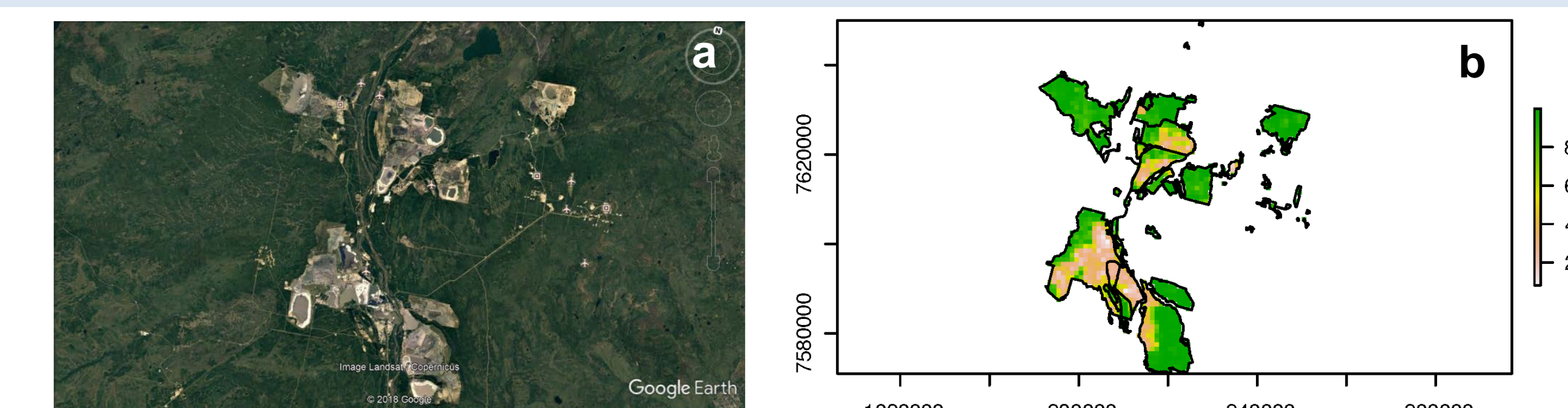


Figure 6. (a) Recent Google Earth image of the seven Athabasca Oil Sands mining facilities (light colored areas) and (b) total vegetation coverage over the same mining facilities based on the new Canadian BELD4 database which does not account for the mines opened after 2001, although it is better than BELD3 (cf. Fig. 1i).

REFERENCES

- Pierce et al., 2000, Development of a 1-km vegetation database for modeling biogenic fluxes of hydrocarbons and nitric oxide. *Sixth International Conference on Air Surface Exchange of Gases and Particles*, July 3-7, Edinburgh, https://www.epa.gov/sites/production/files/2015-08/beld3_web.ppsx
- Beaudoin, A., et al., 2014, Mapping attributes of Canada's forests at moderate resolution through kNN and MODIS imagery, *Can. J. For. Res.*, **44**, 521–532, dx.doi.org/10.1139/cjfr-2013-0401