An evaluation of options to improve GHG emission estimates from forest fires in Sweden

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Outline

1. Background GHG from forest fires in Sweden
   Description of current method

2. Alternative methods
   Description of available data
   Comparisons of results

3. Concluding remarks

The presentation builds on the Master thesis by Markus Reimer !

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Tier 1 (2) Estimation Methods

Sweden (IPCC 2003 GPG)

$$L_{CO2} = A \times B \times \mathbf{44/12}$$

$$L_{N2O} = A \times B \times \mathbf{0.01} \times \mathbf{0.007} \times \mathbf{44/28}$$

$$L_{CH4} = A \times B \times \mathbf{0.012} \times \mathbf{16/12}$$

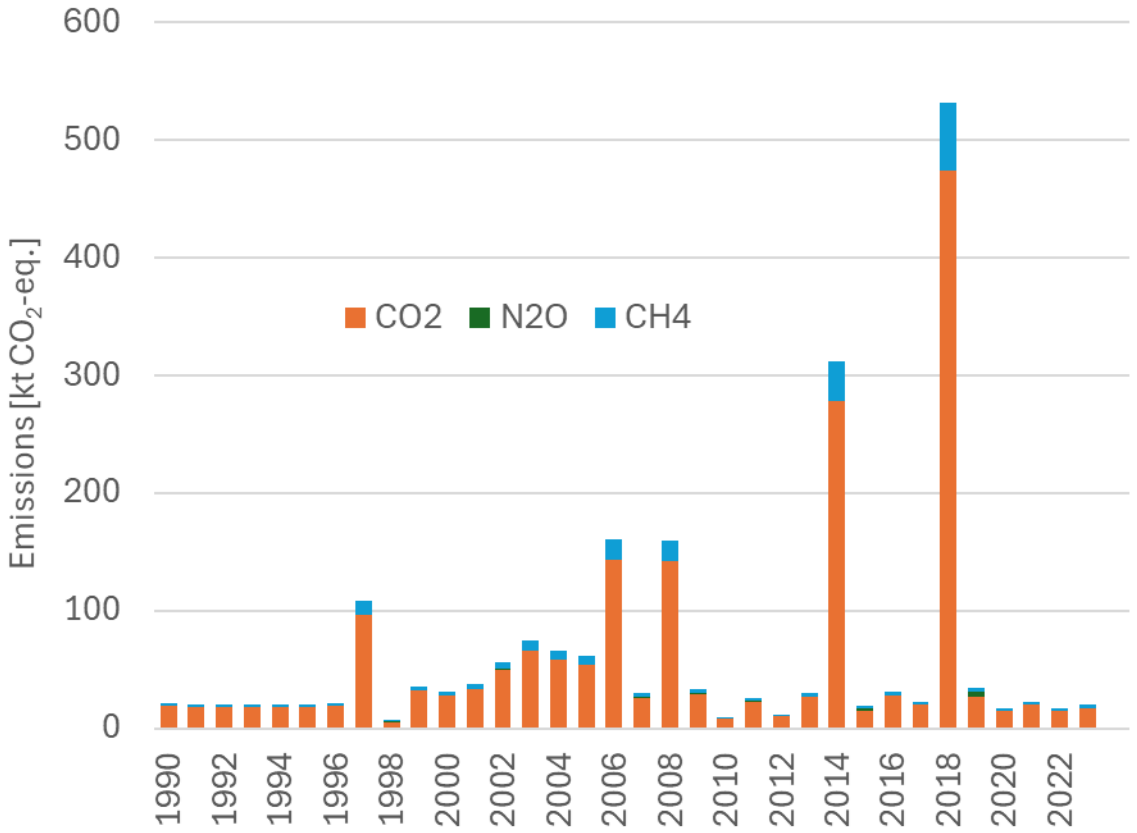
$$B = M_B \times C_f \times C_{frac}$$

Reporting (Sweden):

CO_2 **as CSC in CRT 4.A under 4.A.1 and 4.C under 4.C.1**

N_2O **and** ***CH_4*** **in CRT 4(V)**

Biomass burning emissions represent 0,1% of LULUCF Net removals (on average)



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Reporting (Sweden):

CO_2 as CSC in CRT 4.A under 4.A.1 and 4.C under 4.C.1

N_2O and CH_4 in CRT 4(V)

IPCC 2006 GL

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

L = GHG emissions [t]

A = ***Area*** $[ha/yr]$

B = ***Biomass*** $[tDM/ha]$ (SE 46, IPCC 41)

C_{frac} = ***Carbon fraction (0,5)***

C_f = ***Combustion Factor*** (SE $\mathbf{0.25}$, $IPCC$ $\mathbf{0.34}$)

$Numbers(SE)$ = ***Emission Factor*** $(molar)$

G_{ef} = ***Emission Factor*** $(\mathbf{1569}, \mathbf{0.26}, \mathbf{4.7})$

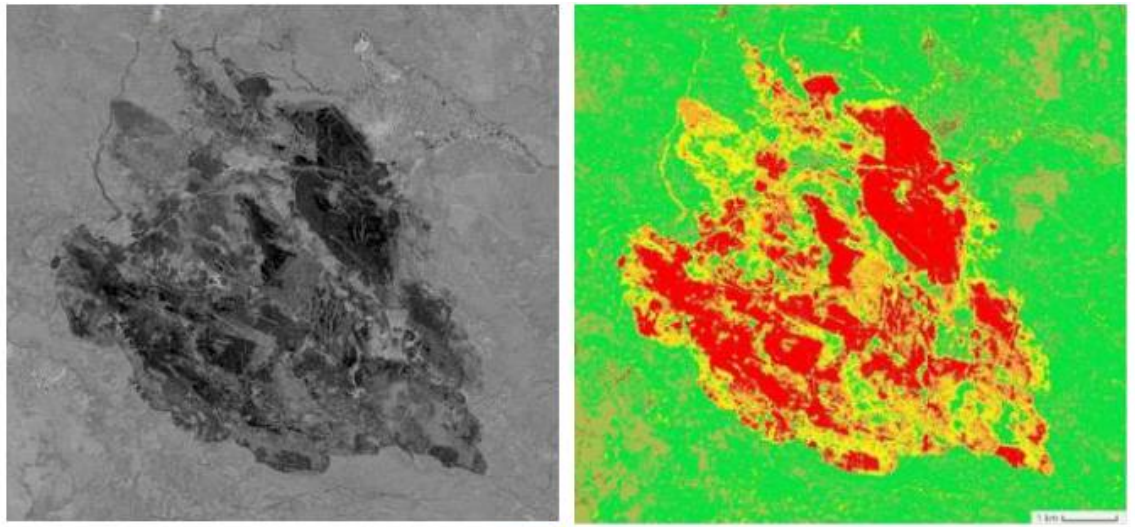
Available data

Source	Data	Format
• National Forest Inventory (NFI)	Biomass | Land use	Sample survey | Statistics on different spatial scales
• Swedish Forest Agency (SKS)	Forest Basic Data (laser scanning) | Fire Polygons	10x10 m grid forest data | vector (RS detected fire areas)
• Swedish Contingency Agency (MSB)	Fire Incident Database (field based)	Coordinates and area of different fire types
• Swedish Environmental Protection Agency (SEPA)	NMD Land Cover Database	10x10 m grid land cover based on RS and other sources

Burned areas

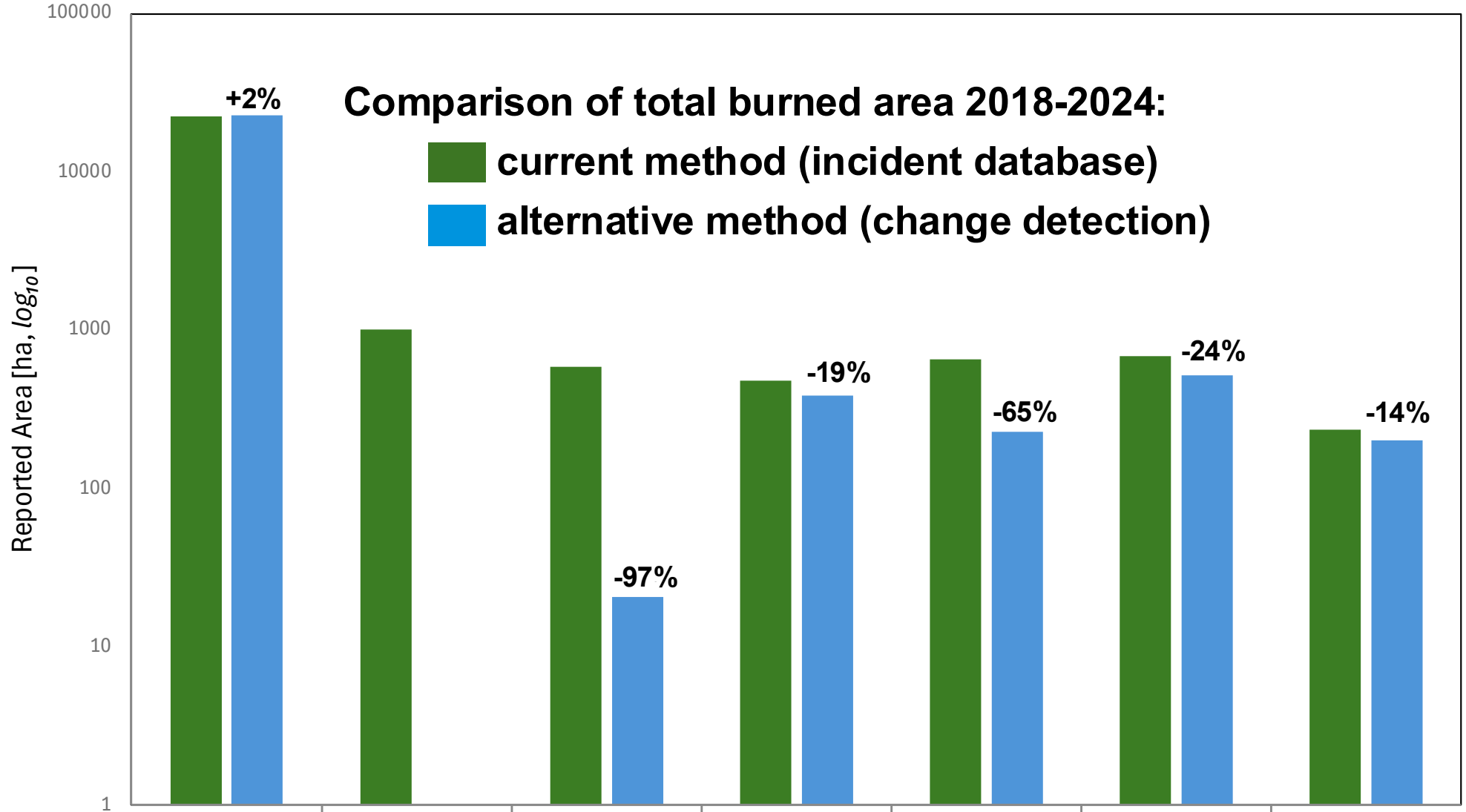
	Who?	What?	Data representation
Current method	MSB	Incident database of individual fires reported by the fire brigades	Total area of wildfires in three categories: Productive forest, Other forest, No tree cover. Total area of Nature conservation burnings and Regeneration burnings
	SKS	Reported conservation and regeneration burning	
Alternative method	SKS	Manually delineated polygons visually derived from satellite image comparisons (Sentinel 2)	Areas categorised into: Wildfire, Nature conservation burnings, Regeneration burnings

Left: Satellite image before fire. Right: Satellite image after fire.
(from Bäckstöm et.al. 2019)



Left: Burned area using normalised Burn ratio (NBR). Right: classificaition of severity from the NBI-image.
(from Bäckstöm et.al. 2019)

Bäckström, L. & Grenert, P. 2019. Damage Assessment of the 2018 Swedish Forest Fires Using Sentinel-2 and Pleiades Data. BSc thesis, KTH Royal Institute of Technology, 1-36 s.

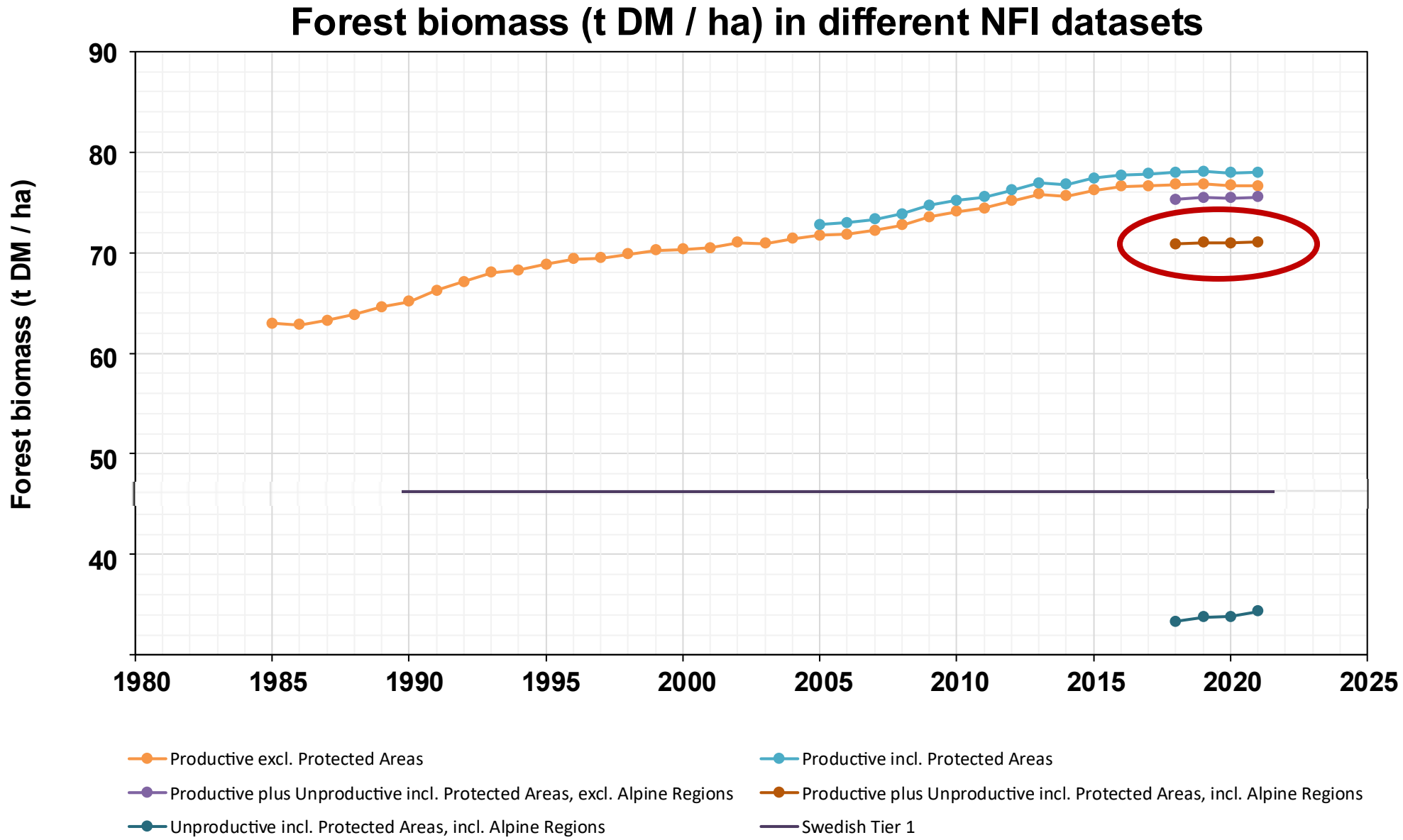


Annual area (ha)

	2018	2019	2020	2021	2022	2023	2024
MSB	22453	1006	592	478	656	687	236
SKS(v.1)	22866	0	21	385	229	520	203

Biomass (dry matter per hectare)

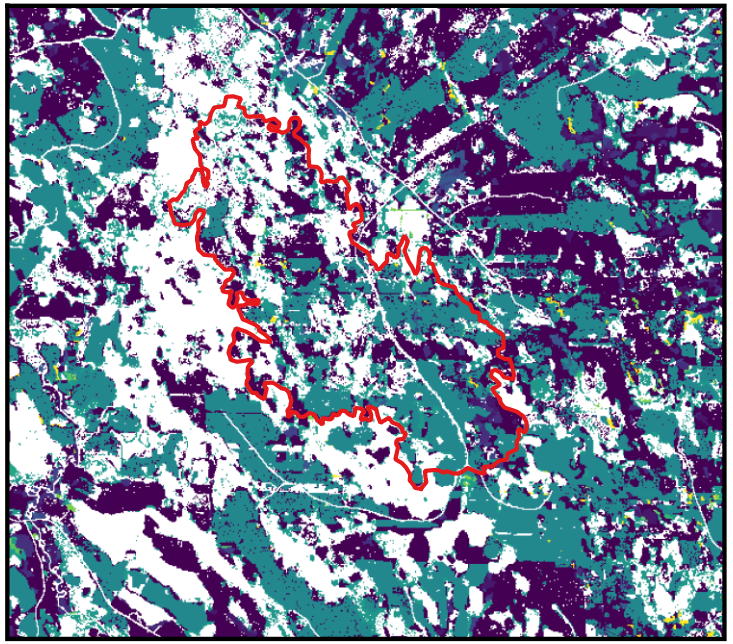
	Source	Data representation	Approach	
Current method	NFI	Fixed historical value 46 t DM / ha	Same value used for the entire time seried	
Alternative method 1	NFI	Annual data from NFI	Annual value used together with the annual burned area	National totals County based
Alternative method 2	SKS	Observed fires and spatial ALS biomass data	Biomass represents the actual affected area each year	

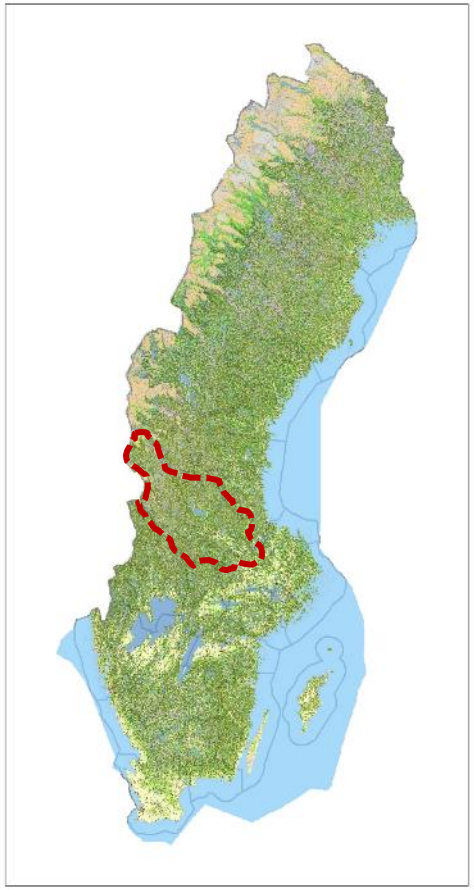

Forest biomass (t DM / ha) in different NFI datasets
Forest biomass (t DM / ha)
90
80
70
60
50
40
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Productive excl. Protected Areas
Productive incl. Protected Areas
Productive plus Unproductive incl. Protected Areas, excl. Alpine Regions
Productive plus Unproductive incl. Protected Areas, incl. Alpine Regions
Unproductive incl. Protected Areas, incl. Alpine Regions
Swedish Tier 1

Forest biomass estimates for detected wildfires in Dalarna county

Biomass masking process to exclude non-forested areas from the ALS-derived biomass raster map

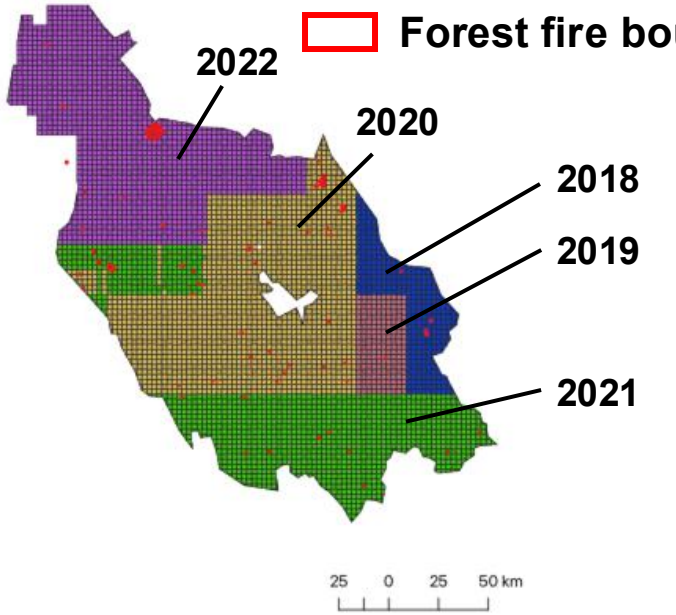
Forest fire boundary





Dalarna ALS scan year blocks

Forest fire boundary

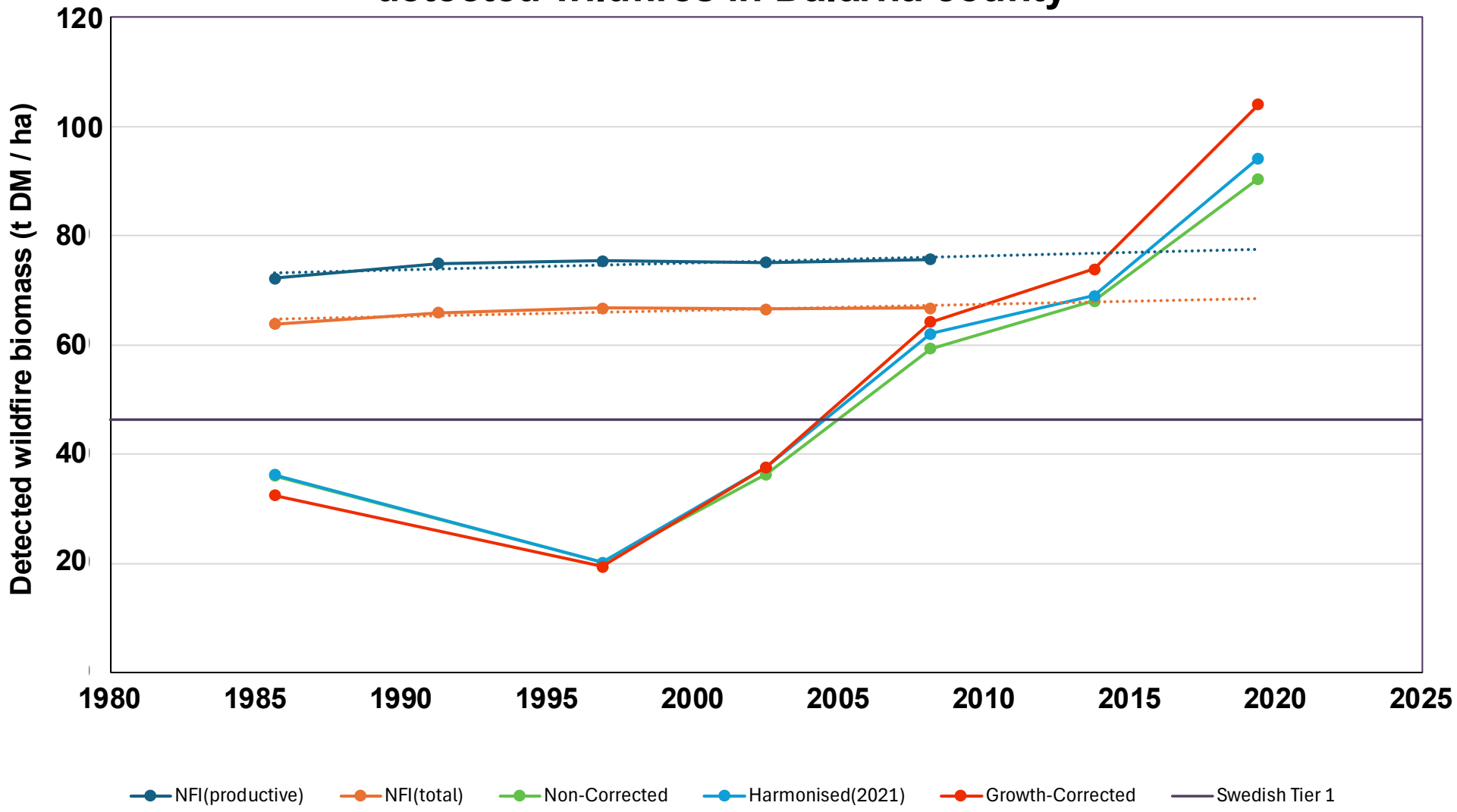


Biomass raster correction:

$$biomass_{2021} = biomass_{ALS} \times \left(1 + 0.035 \times \left(2021 - ALS_{year}\right)\right)$$

Correction for disturbances

Different forest biomass estimates for detected wildfires in Dalarna county



Combustion factor (field visits)

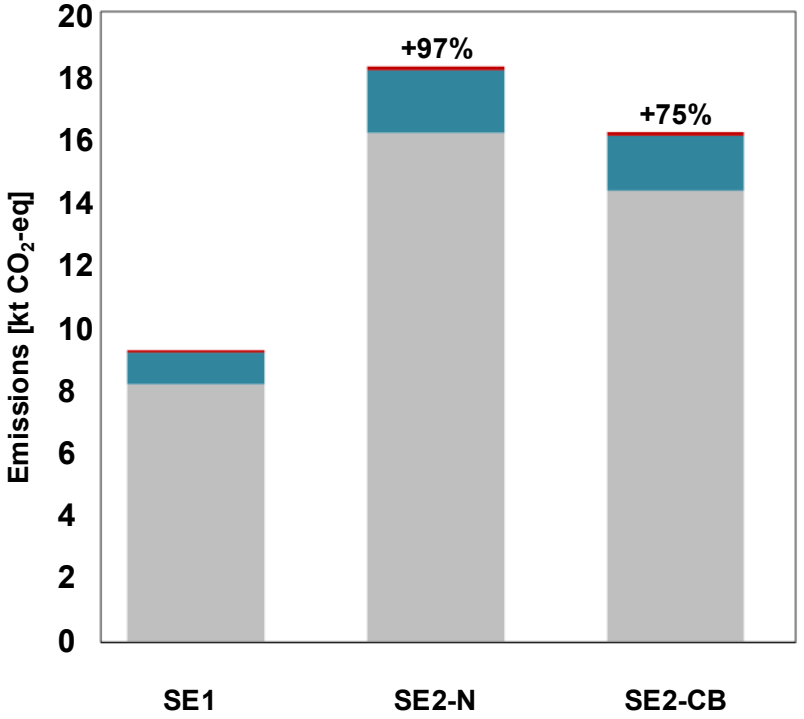



- Fires visited burned in relatively low severity
- Living tree biomass combusted well below 25 %
- Dead wood, litter and humus where affected to varying degree

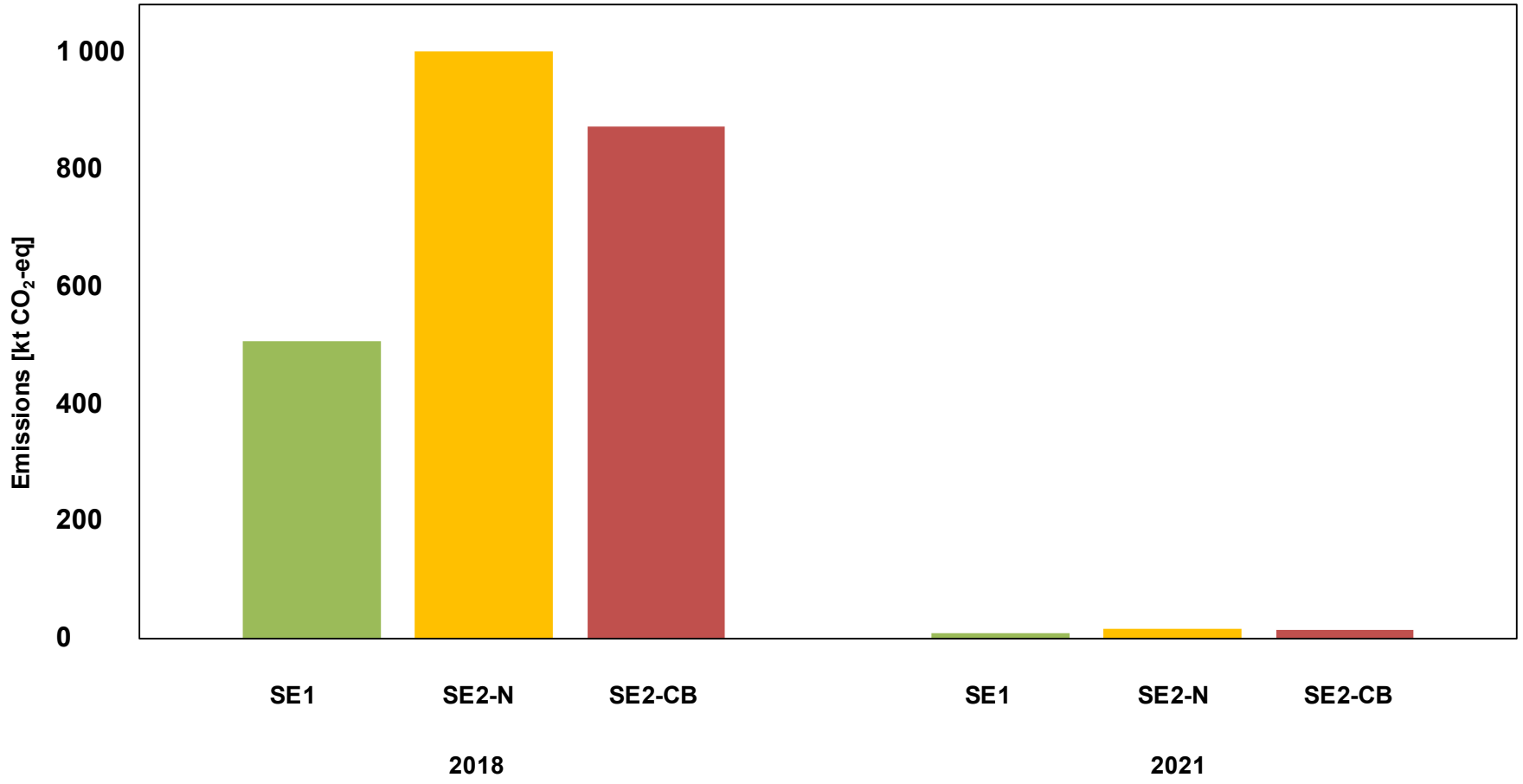
Emissions

	Name	Biomass	Area
Current method	SE1	Fixed historical value: 46 t DM / ha	Total burned area in different categories
Alternative method 1	SE2-N	Updated national value: 91 t DM /ha	Total burned area in different categories
Alternative method 2	SE2-CB	County based data from NFI	Area burned per county

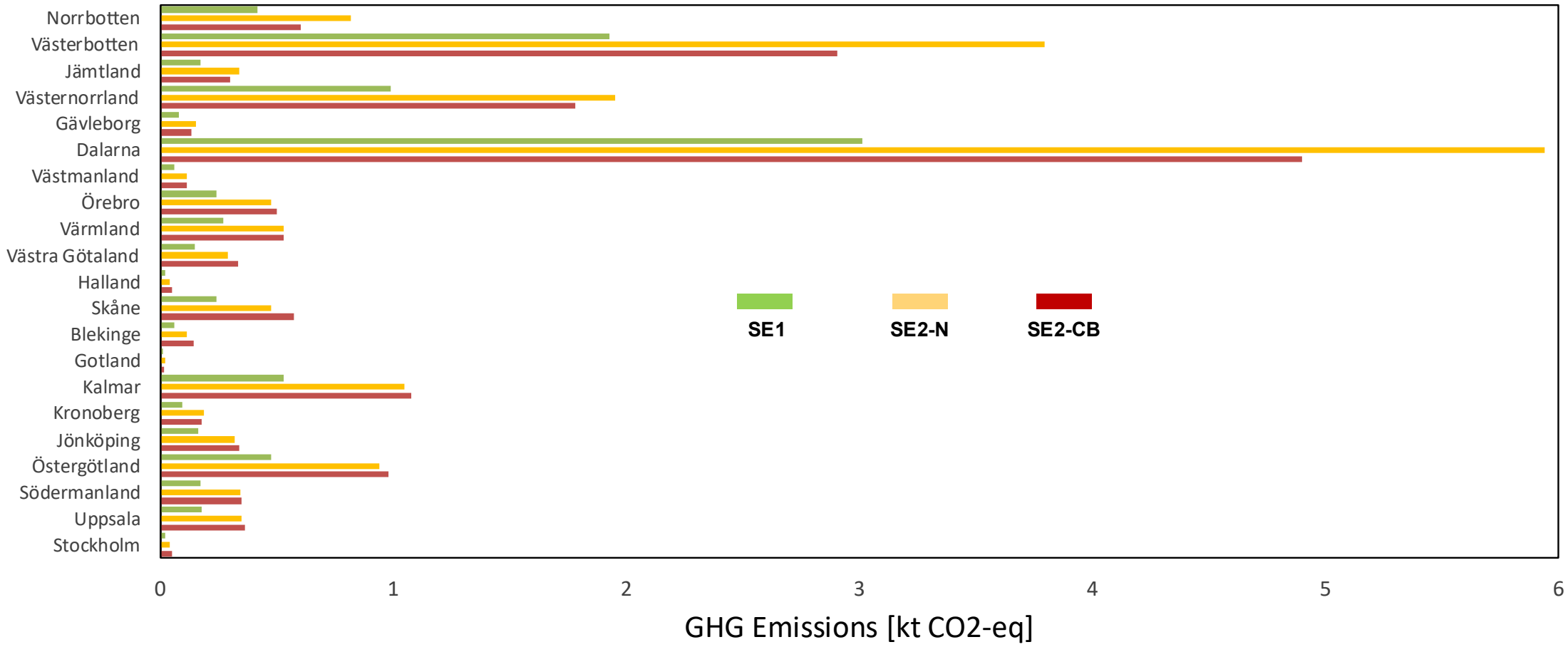
Total GHG emissions from forest fires in Sweden 2021



Total GHG emissions from forest fires in Sweden 2018 (extreme year) and 2021 (normal year)



Total GHG emissions from forest fires in Sweden 2021 by county and method



Conclusions

Area estimates

- SKS wildfire polygons got better in recent years, but problems with smaller fires
- MSB data is not perfect (deliniation)

Controlled Fires

- Available data suffers definition problem (FSC incentives)
- Survey based → error in reporting hard to check

Biomass

- Biomass value used in current inventories is outdated
- Polygon-estimated biomass works, but needs refinement and longer time series
- Classification of land cover burned is important for assigning correct biomass value

Combustion factor

- Fires visited burned in relatively low severity
- Living tree biomass combusted well < 25 %
- Dead wood, litter and humus where affected to varying degree

Emissions

- Annual national totals 75-97% higher with alternative methods
- County-level data show that fixed national values sometimes misrepresent emissions, especially in biomass-rich southern and biomass-poor northern regions
- In high-fire years like 2018 the choice of method plays a larger role for the total emissions

Suggested improvements:

Short term (1-2 years)

- Update biomass values using recent NFI data.
- Refine emission factors for regeneration and conservation burns.
- Coordinate with SKS and MSB to improve fire polygon data and metadata.
- Apply county-level NFI averages for regionally specific emission estimates.

Medium term (2-5 years)

- Test fire-specific biomass estimates using growth and disturban
- Develop s dNBR) to factor est
- Align defi GHG inve standards.
- Expand prescribed burn surveys to include large private owners and county boards.

Long term (5+ years)

- Develop national fire severity mapping using remote sensing for n factors

en MSB, LU for and continuous GHG dataset improvement.

Need to take into account the relative magnitude (low) of emissions from forest fires in Sweden when improvement activities are prioritized.

Thank you for listening!

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