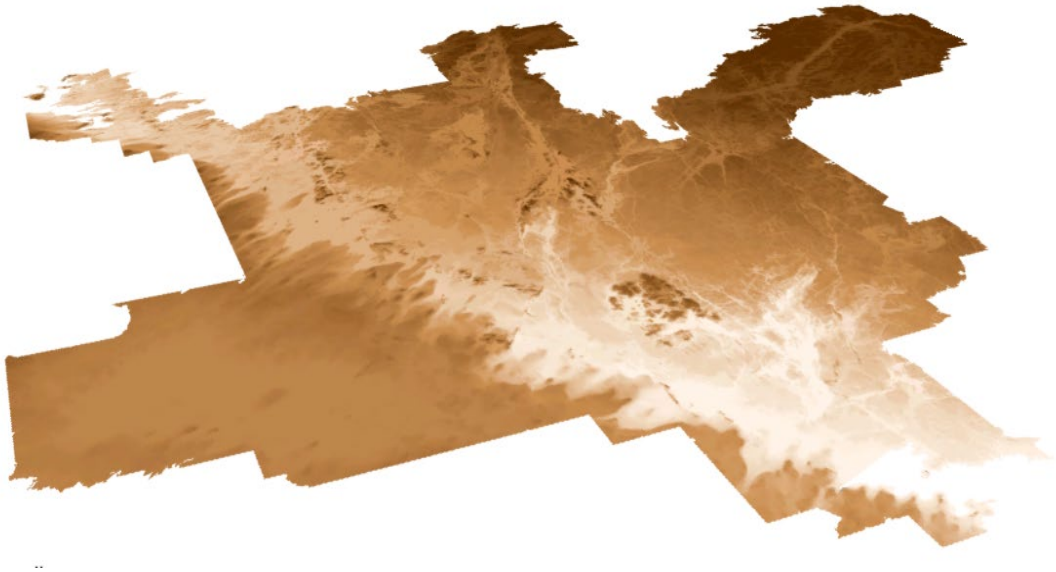
Wildfires in the Tłı̨chǫ Region and Their Effects on Land Cover



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University of Alberta

Objectives

- To analyze how much of the Tłı̨chǫ land has changed over the years
- To understand what factors cause wildfires
- To study ways of reducing wildfire risks by incorporating indigenous knowledge and expertise

Research questions

Q1) How much area was burned in the Tłı̨chǫ land?

Q2) Have all parts of the Tłı̨chǫ and NWT lands experienced the same surface temperature changes over the past two decades? Are there any hot spots?

Q3) Did Tłı̨chǫ land undergo noticeable land cover changes over the past two decades?

Q4) Is there any relationship between land surface temperature, land cover, soil moisture level (dryness), and burn severity

Q5) How can indigenous knowledge be used to reduce the risks linked with wildfire?

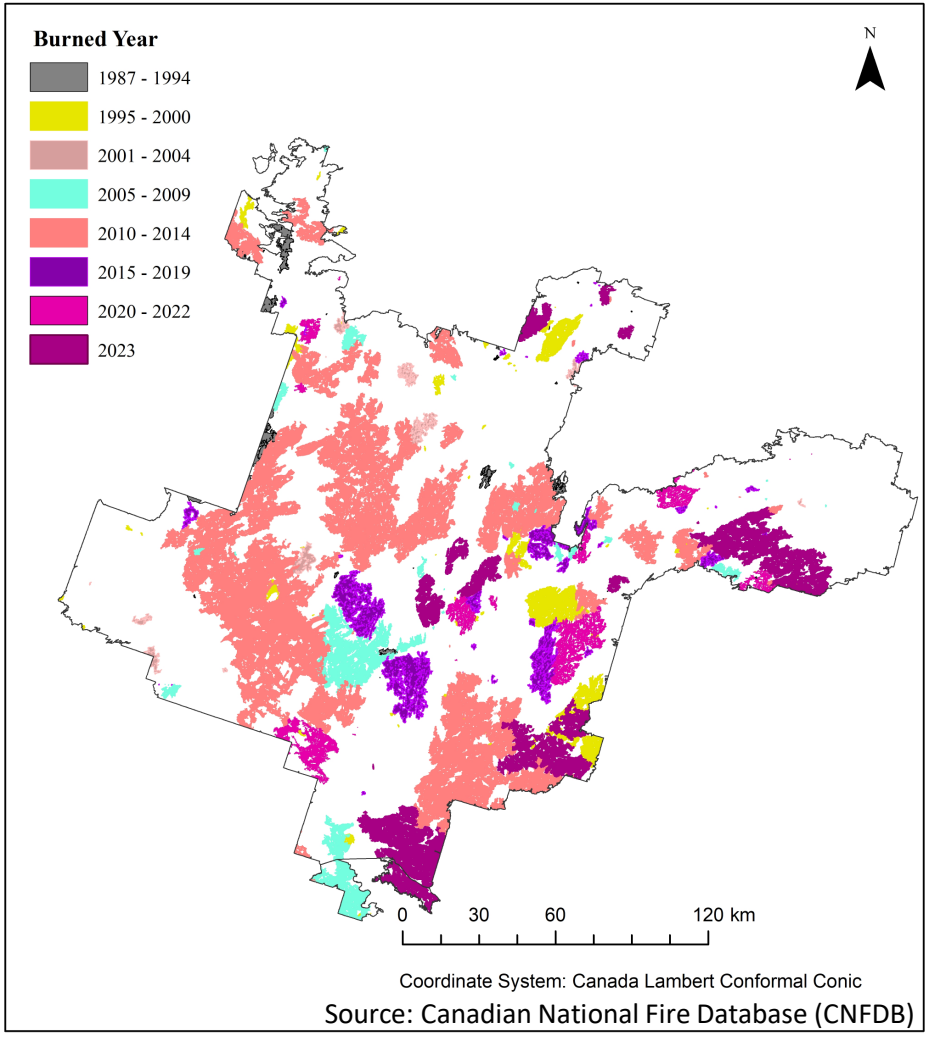
Methodology

Earth Observation data


Source: NASA

Variable	Data Source
1. Burned areas	1987-2022 data: Natural Resources Canada- CNFDB 2023: derived from Landsat 9 satellite data (30 m spatial resolution)
2. Land surface temperature	Moderate Resolution Imaging Spectroradiometer (MODIS)/MOD11A2.061 Terra (1 km spatial resolution)
3. Soil and vegetation moisture/dryness Under ground Temperature	Soil Moisture Active Passive (SMAP) L-Band radiometer:SPL3SMP_E.005 SMAP L3 Radiometer Global monthly, up to 100 cm (9 km spatial resolution) FLDAS: Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System (11 km spatial resolution)
4. Climate and weather (Precipitation Wind Humidity)	Daymet V4: gridded estimates of daily weather parameters for Continental North America; derived from selected meteorological station data and various supporting data sources (1 km spatial resolution) ERA5-Land Monthly aggregated - ECMWF Climate Reanalysis Monthly Aggregates (11 km spatial resolution)
5. Land Cover Vegetation type and structure Vegetation mass (Above-Ground Biomass)	North American Land Change Monitoring System (30 m spatial resolution) Derived using MODIS, Landsat 7-8 and RapidEye satellite imagery ESA's Climate Change Initiative (CCI) Biomass project (100 m spatial resolution)
6. Topography Elevation	North American Environmental Atlas (250 m spatial resolution)

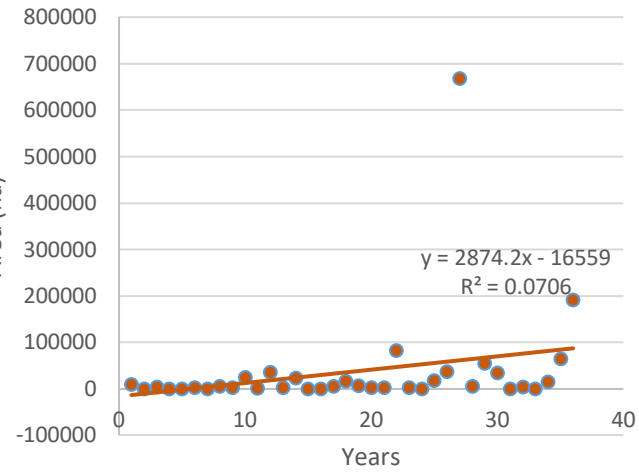
Q1) How much area was burned in the Tłı̨chǫ land?



Source: Canadian National Fire Database (CNFDB)

Total burned areas (1332704 ha) recorded over the past 37 years, with a 6-year interval

Year	Burned area (ha)
1987	9769
1988	225
1989	3818
1990	17
1991	26
1992	2107
1993	42
1994	5470
1995	2716
1996	**23849**
1997	665
1998	**35662**
1999	2315
2000	**22540**
2001	26
2002	37
2003	5345
2004	**16781**
2005	6922
2006	2296
2007	2702
2008	**81713**
2010	2765
2011	107
2012	**17808**
2013	**37031**
2014	**667992**
2015	5037
2016	**54488**
2017	**33736**
2018	193
2019	3429
2020	24
2021	**14199**
2022	**64977**
2023	**191308**



From 1987-2023

⅓ of the land burned

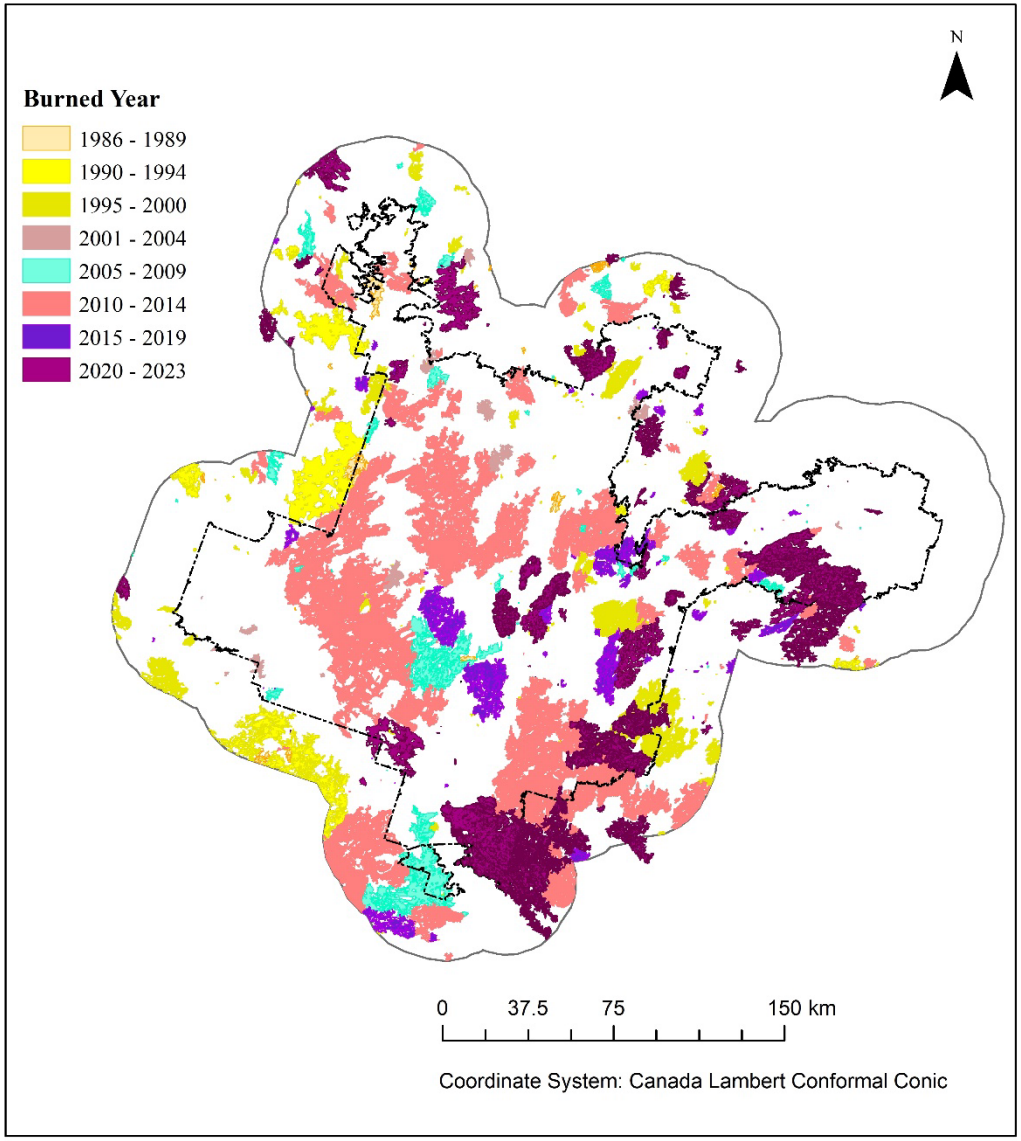
2000—2023

nearly 32% burned

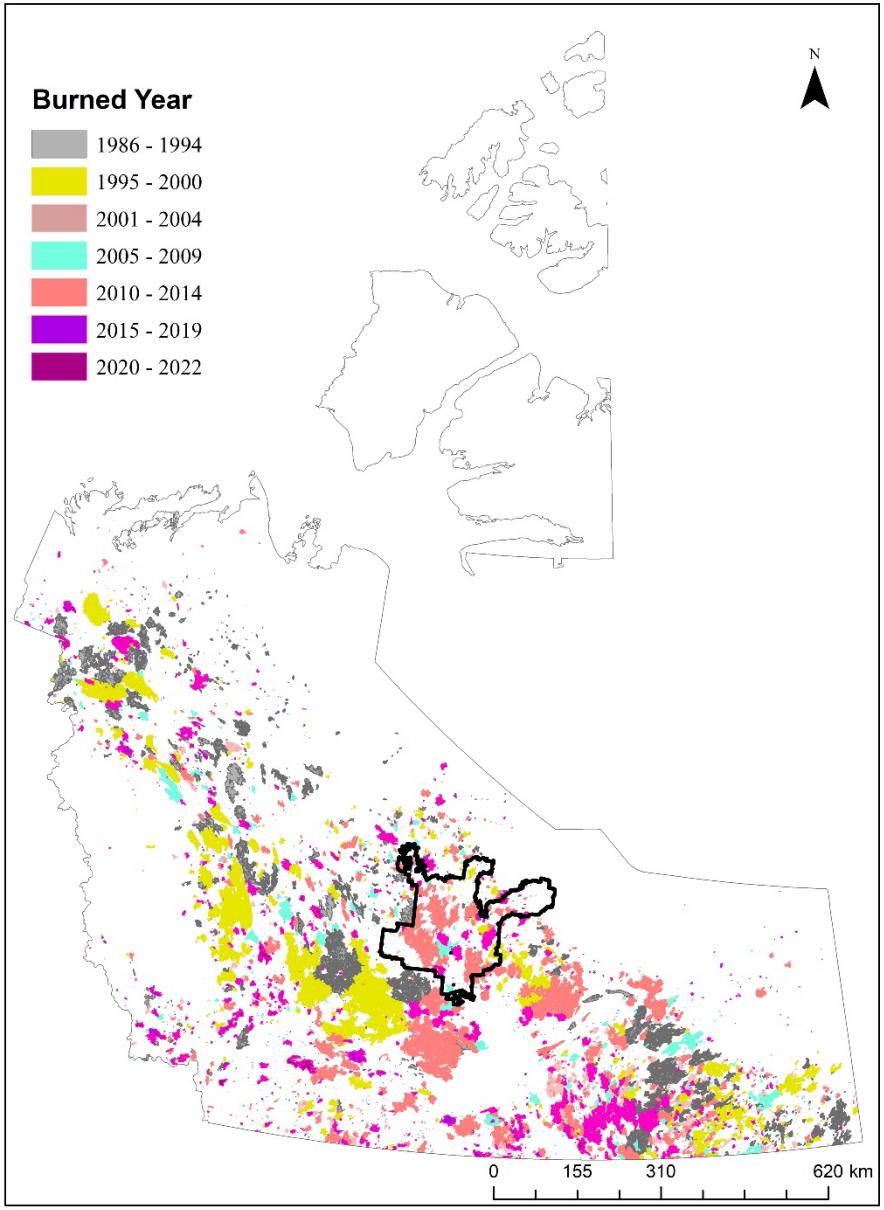
2000—2010 (4%)

2010—2023 (28%)

Spread of wildfires within a 30 km outside buffer zone of the Tłı̨chǫ area



How much area was burned in the NWT?

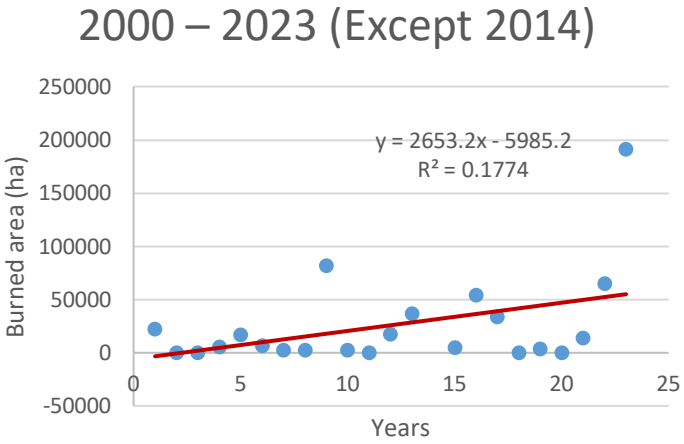


Coordinate System: WGS 1984 UTM Zone 12NTransverse Mercator

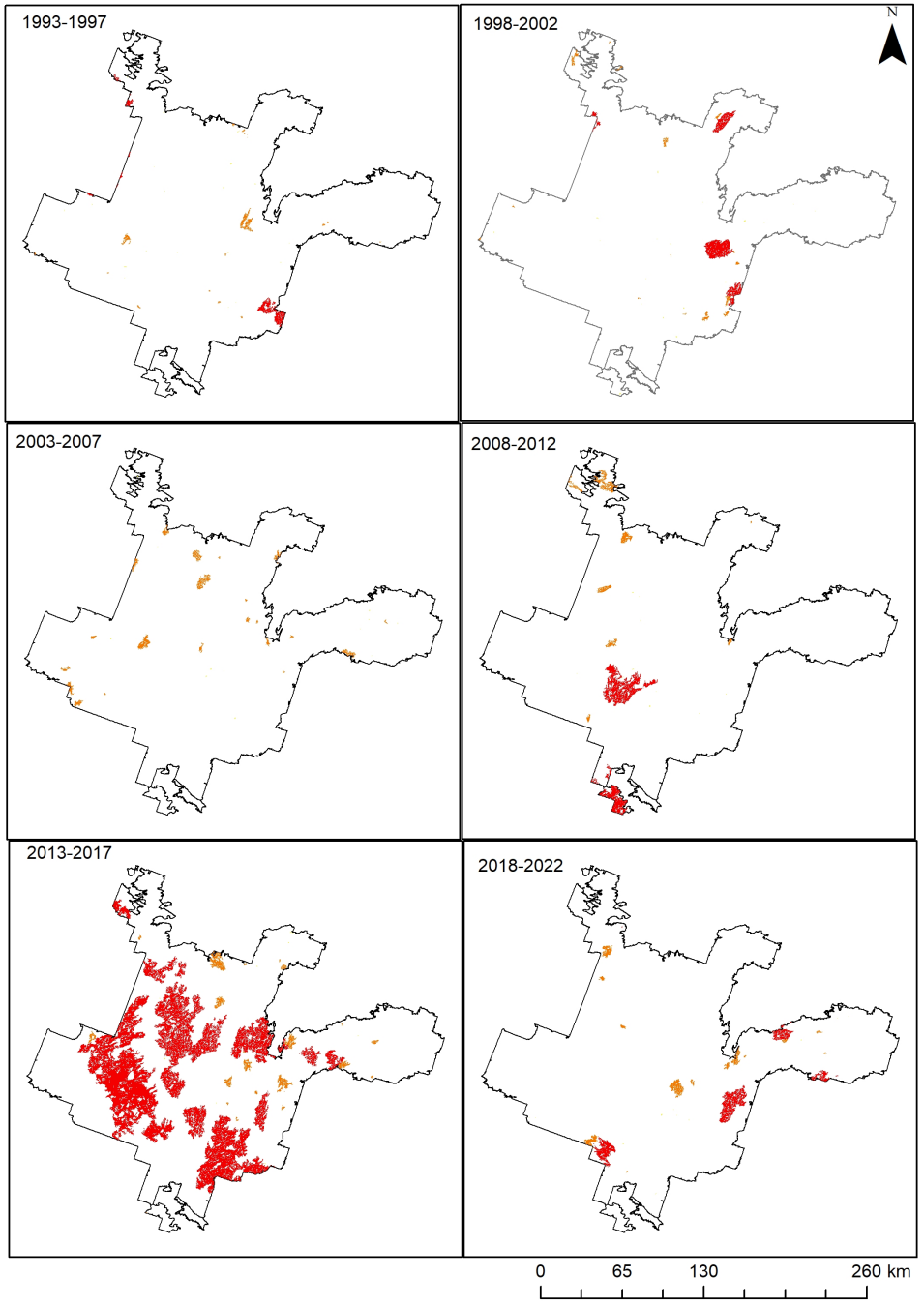
Source: Canadian National Fire Database (CNFDB)

Over the last 37 years,
~18% of NWT land
~ 34% of Tlicho land burned

Mega Fires (> 10,000 ha) in the Tłı̨chǫ Region

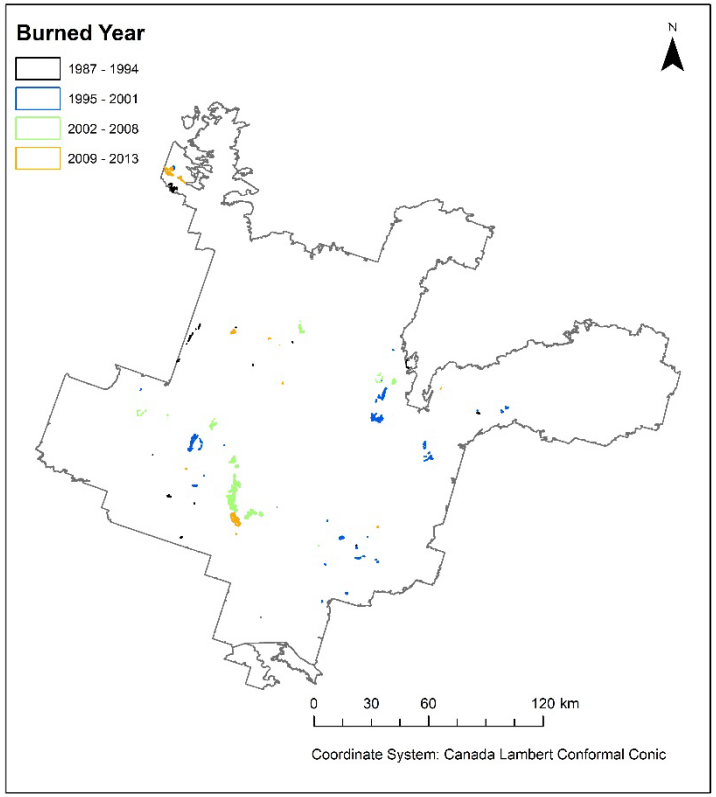


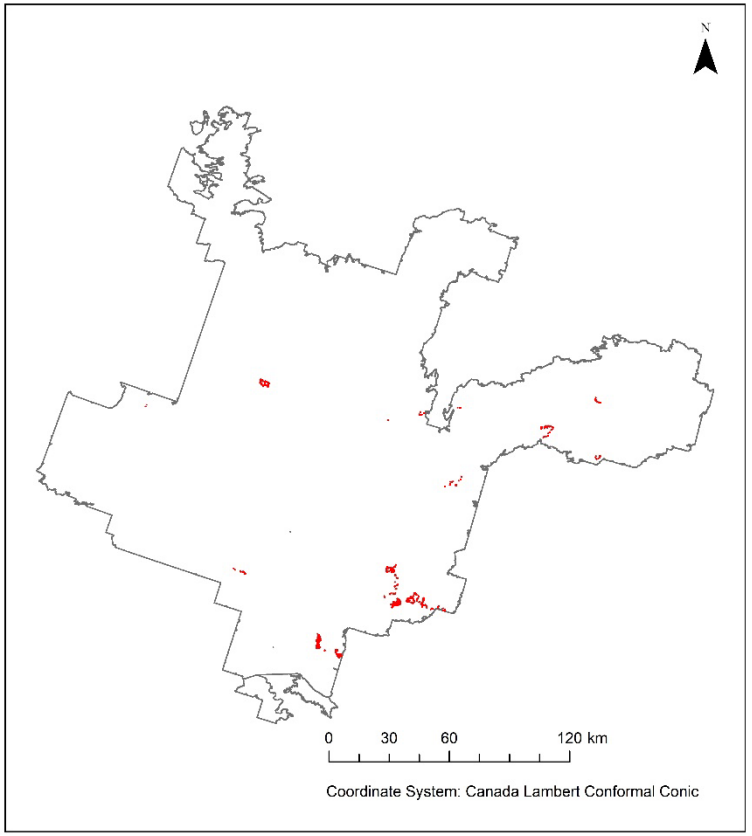
Mega fires occurred in 2008, 2014, 2016, 2022 and 2023



Are some areas experiencing re-burning?

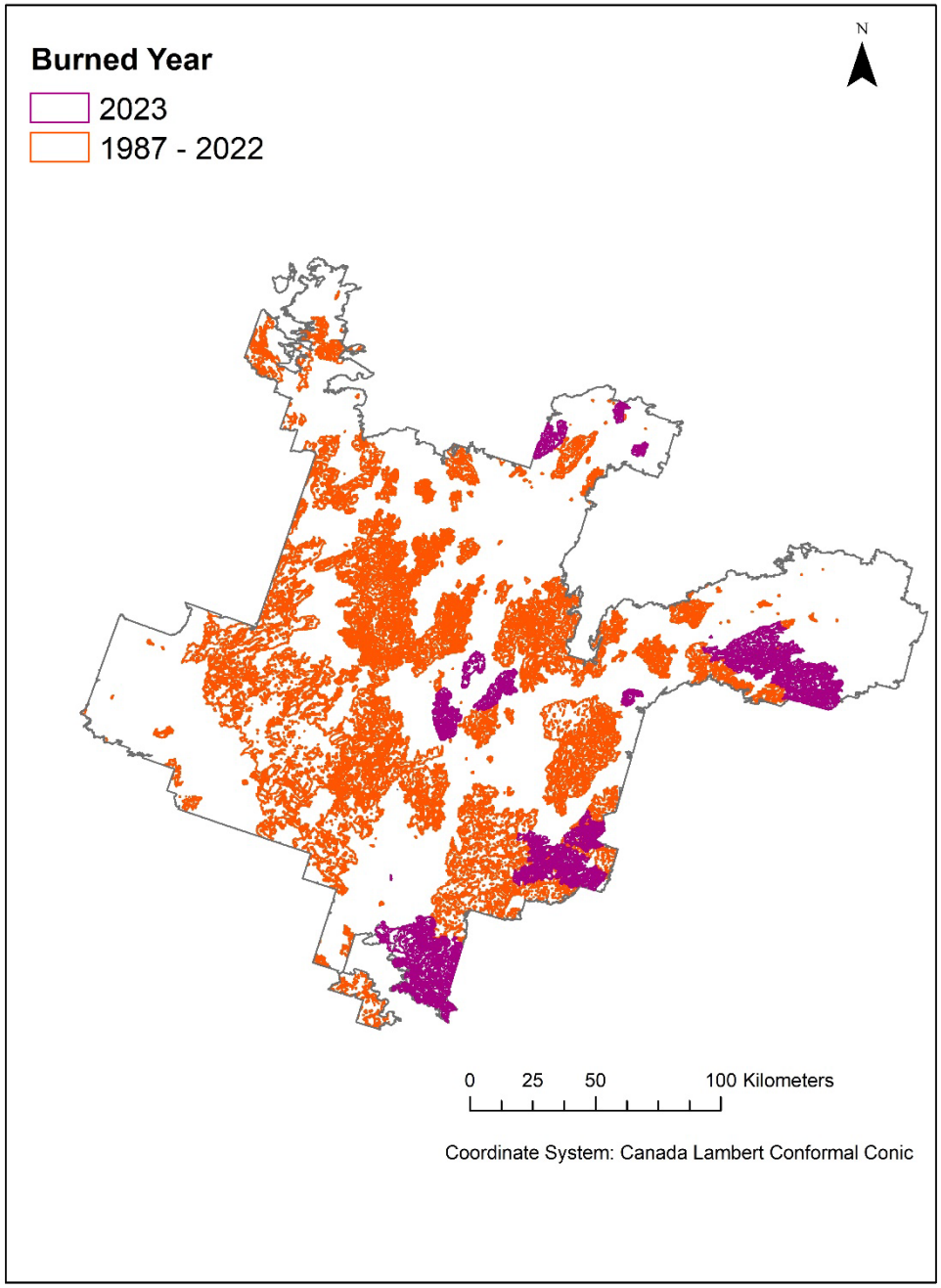
9,400 ha burned prior to 2014 burned again in 2014 (~1.4% of total burned)





3,500 ha burned in 2014 burned again in the fires of subsequent years

Comparison of areas burned by fires between 1987 and 2022 *vs.* 2023



- 11,700 ha burned prior to 2023 burned again in 2023 (~6% of total burned)

What are the factors that mainly influence the wildfires?

Climate and Weather

- Surface temperature ✓
- Precipitation ✓
- Wind *
- Humidity *
- Soil moisture ✓

Topography

- Elevation ✓
- Slope *
- Aspect *

Fuels

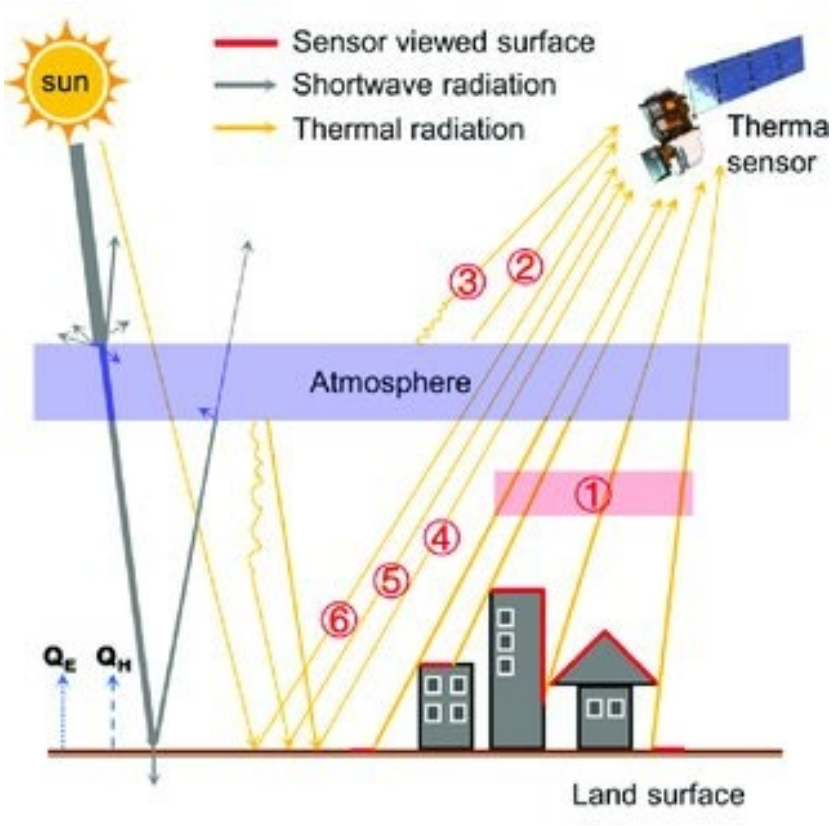
- Vegetation type/ Land cover ✓
- Biomass/Density and height ✓
- Structure: Size and continuity ✓

✓ Tasks completed

* - Tasks are remaining

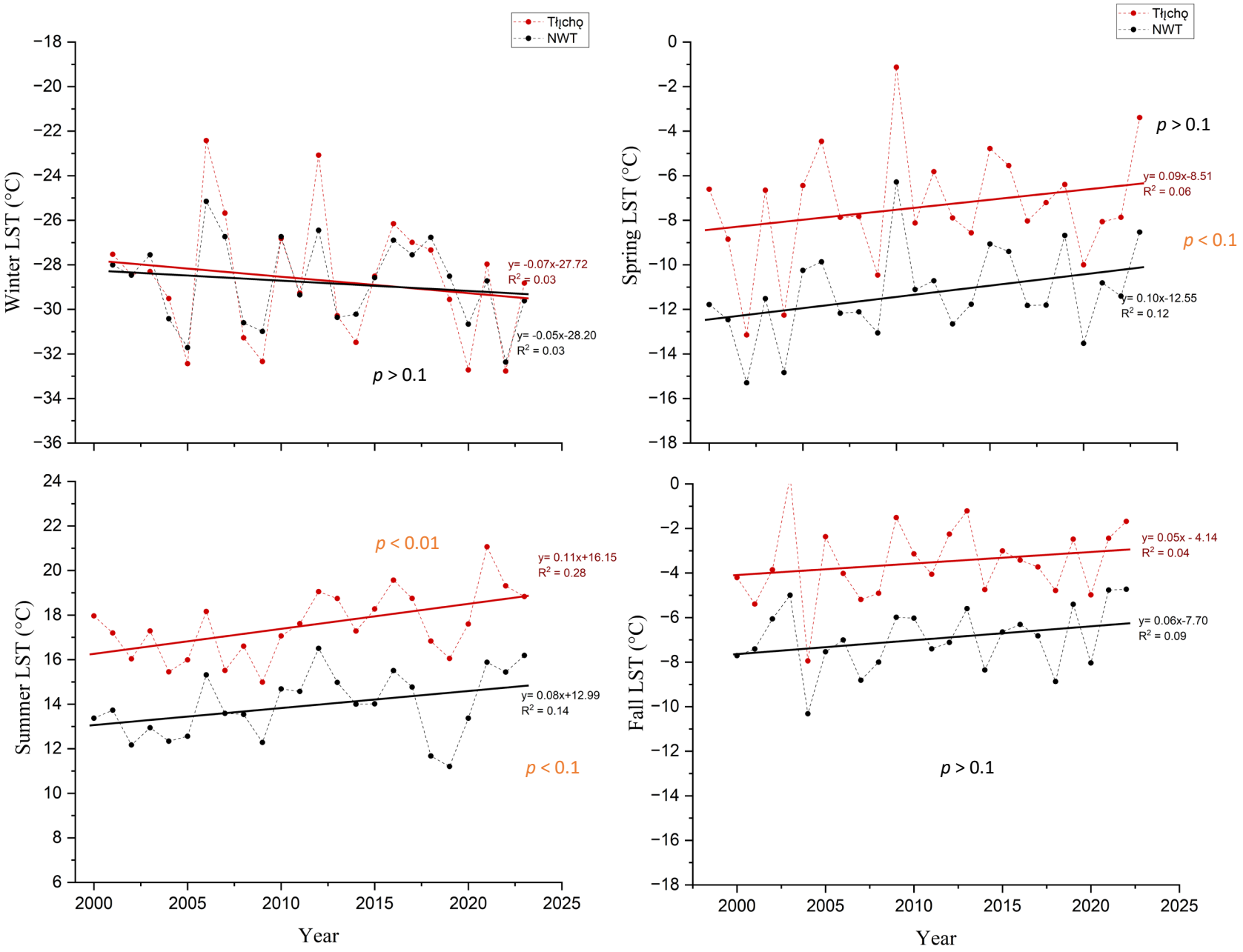
Q2) Have all parts of the Tłı̨chǫ and NWT lands experienced similar surface temperature changes over the past two decades? Are there any hot spots?

Measuring Land Surface Temperature

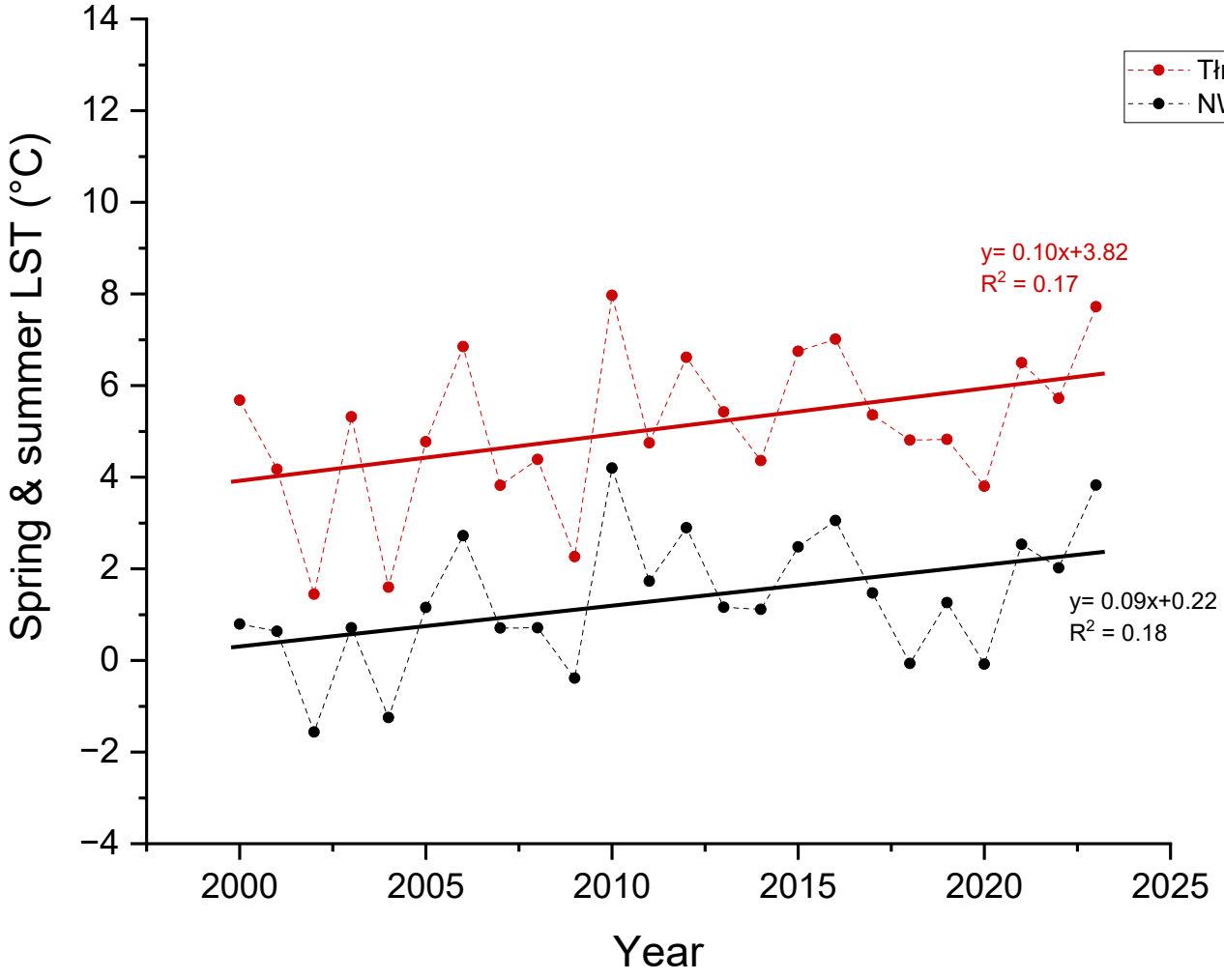


Source: Zhou et al. 2018

Seasonal land surface temperature changes from 2000 to 2023



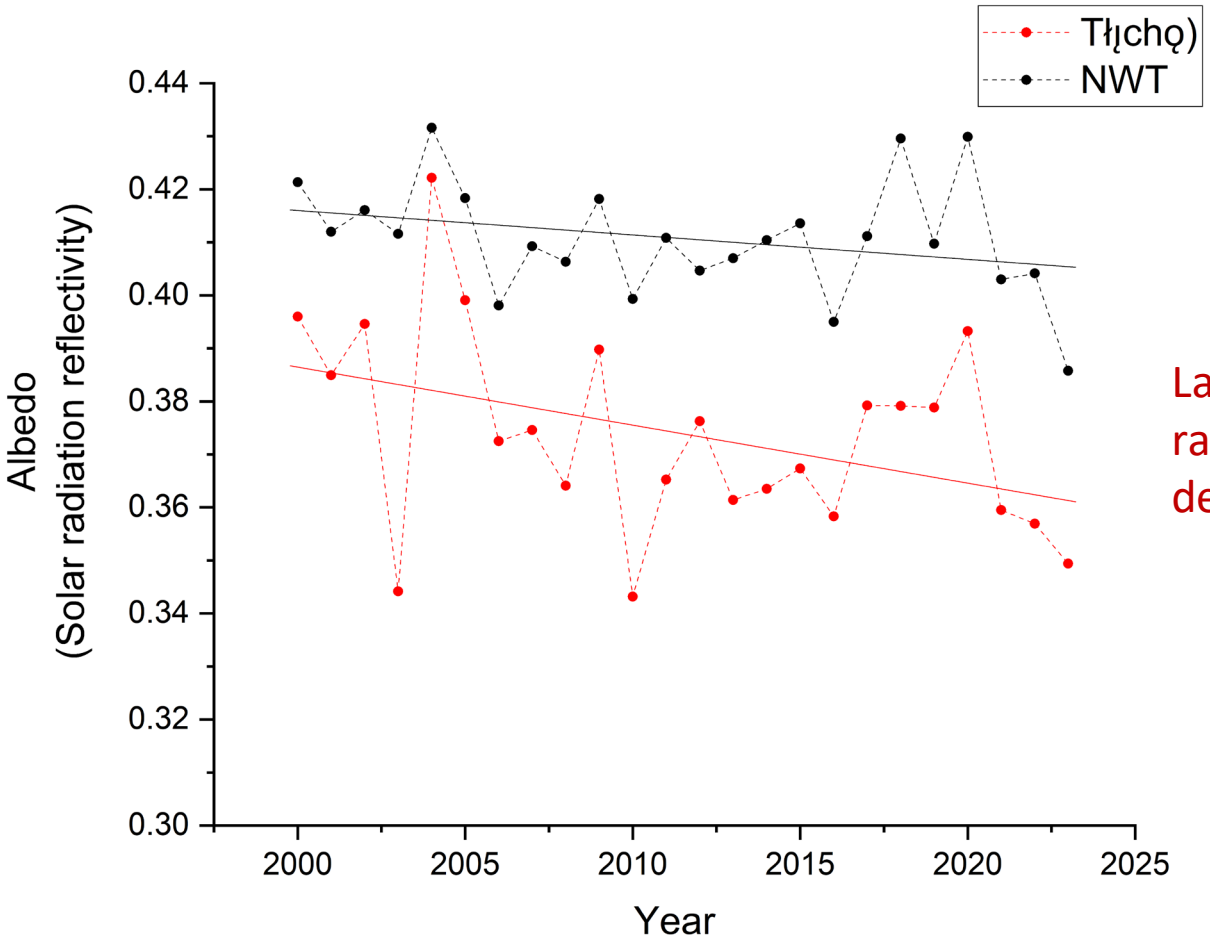
Spring and summer land surface temperature changes from 2000 to 2023



$p < 0.05$

There has been a significant increase in surface temperature over the last two decades.

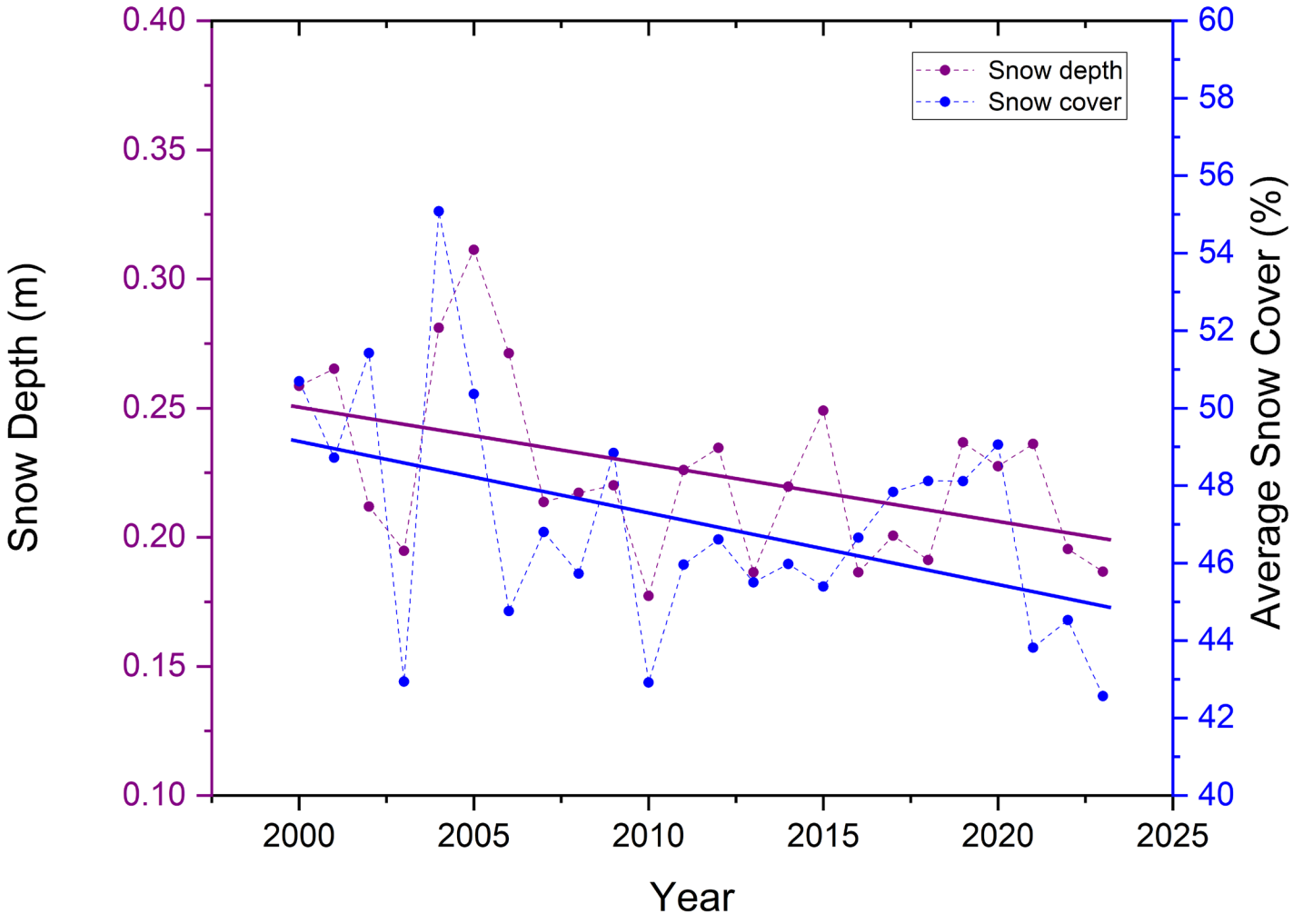
Why has Tłı̨chǫ land shown a higher warming rate than the NWT land over the past 24 years?



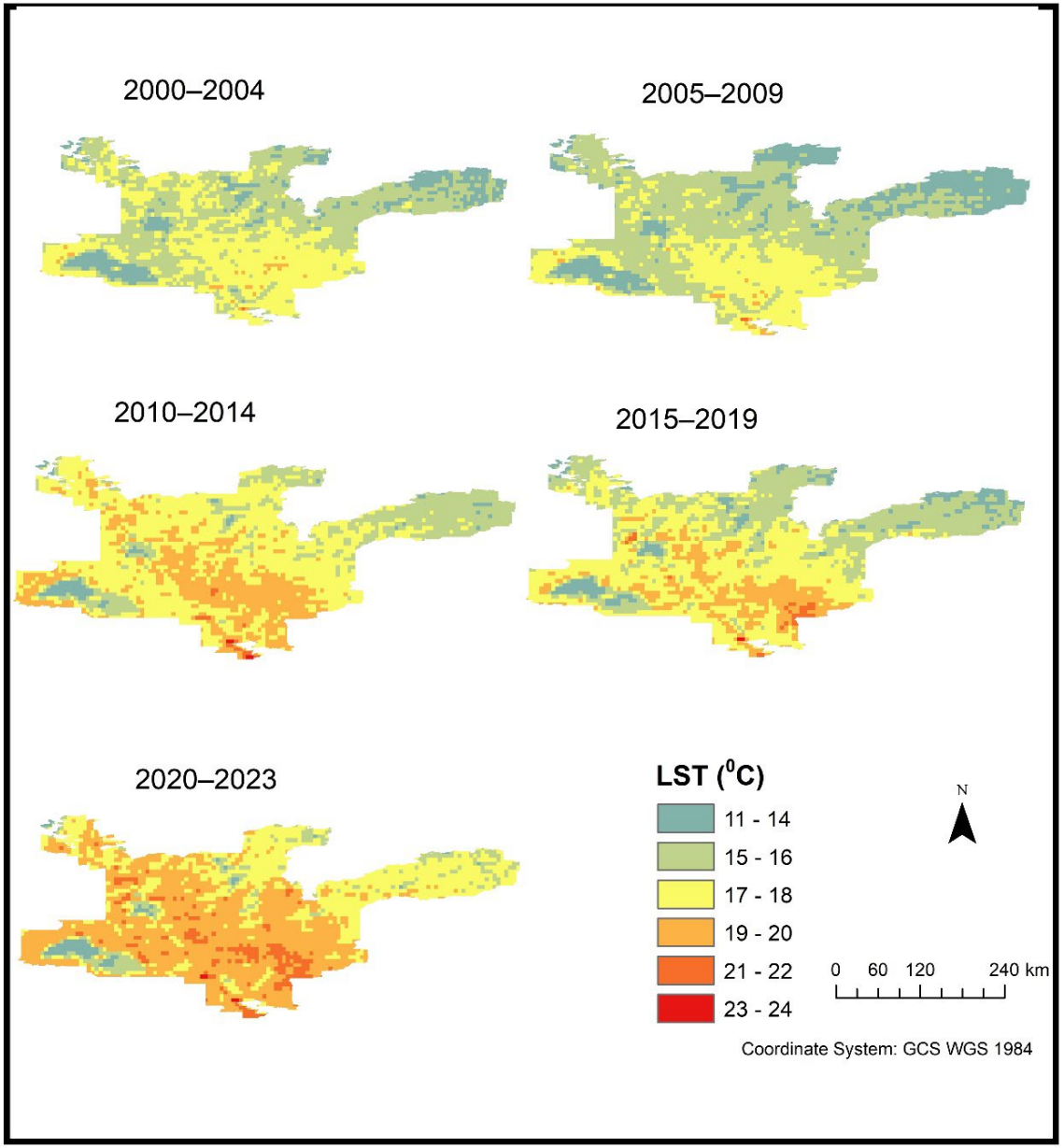
Land now absorbs more solar radiation due to a significant albedo decrease in the last two decades.

Albedo is a measure of the solar radiation reflectivity of the Earth's surface.

Temporal changes of snow cover in Tłı̨chǫ Land



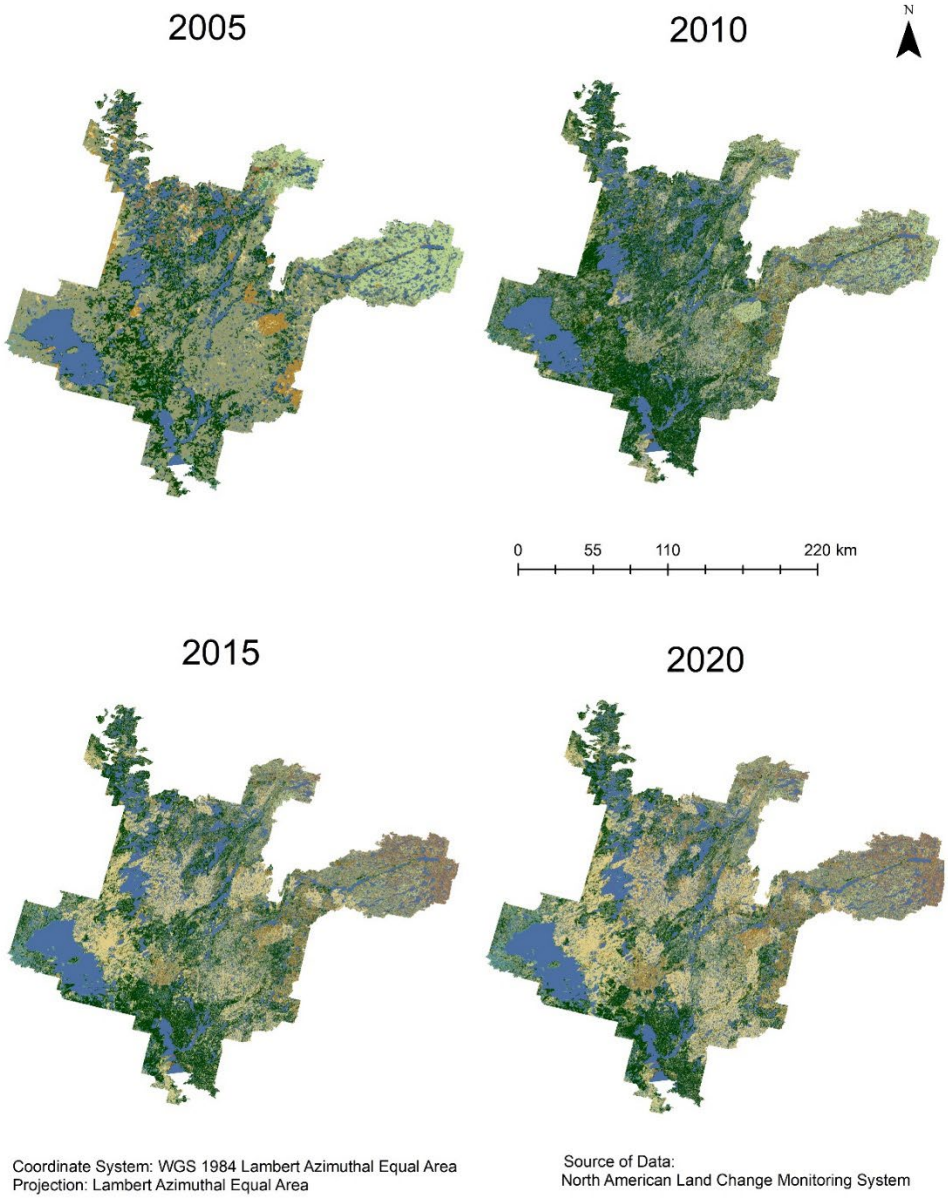
Changes in average summer (June, July and August) land surface temperatures from 2000 to 2023



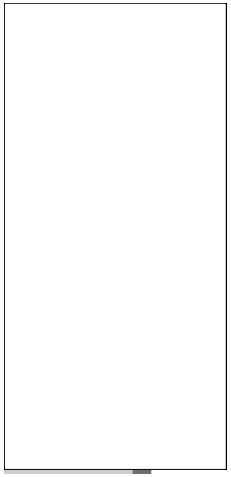
The areas exposed to higher LST have increased.

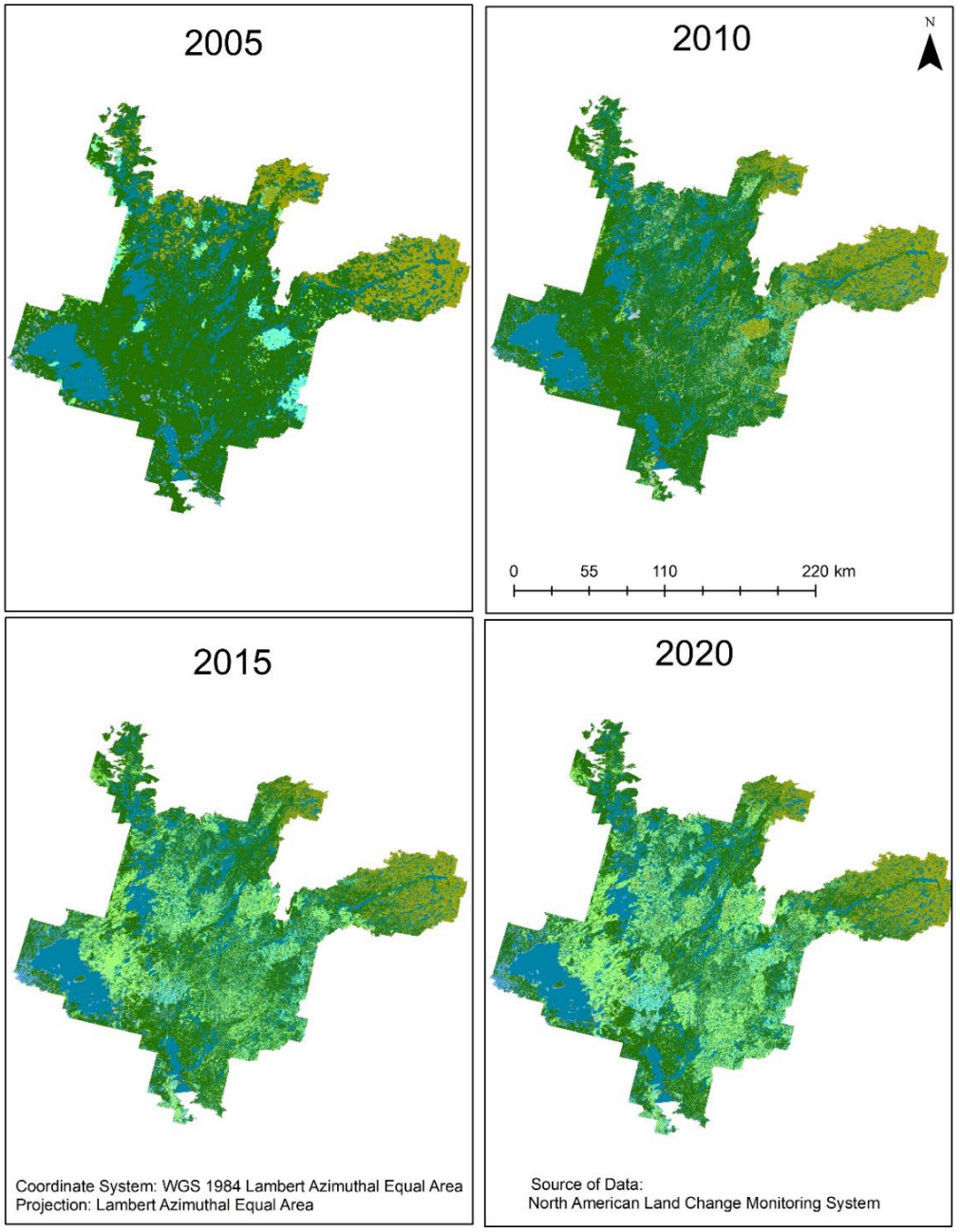
Q3) Did Tłı̨chǫ land undergo noticeable land cover changes over the past two decades?

(Source: United Nations standard land covers)



Major land cover changes



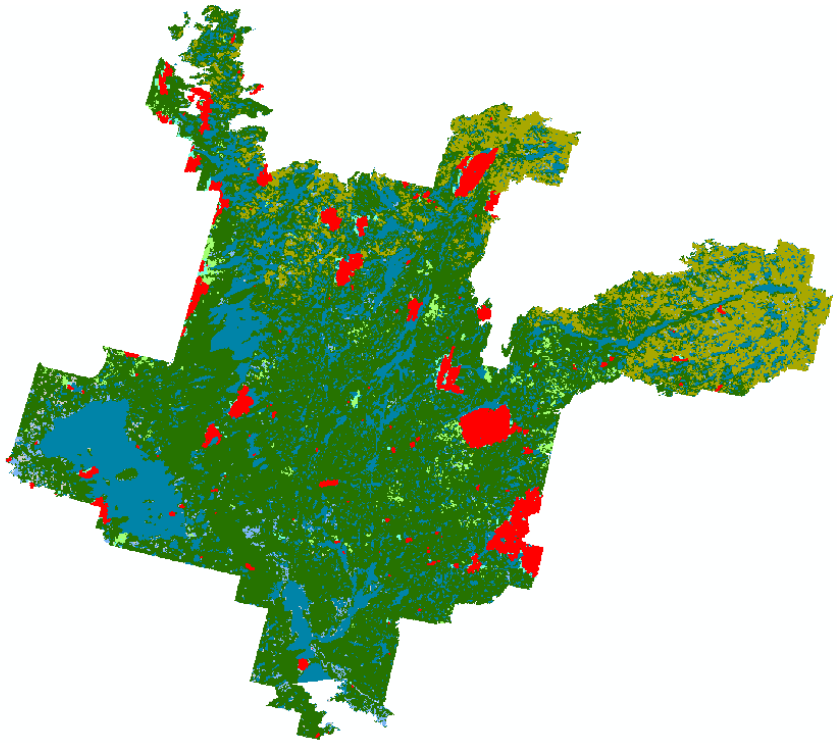


Forest area reduced to nearly half, by 46%
Shrub lands and barren lands were doubled
Grasslands increased by nearly 10 times

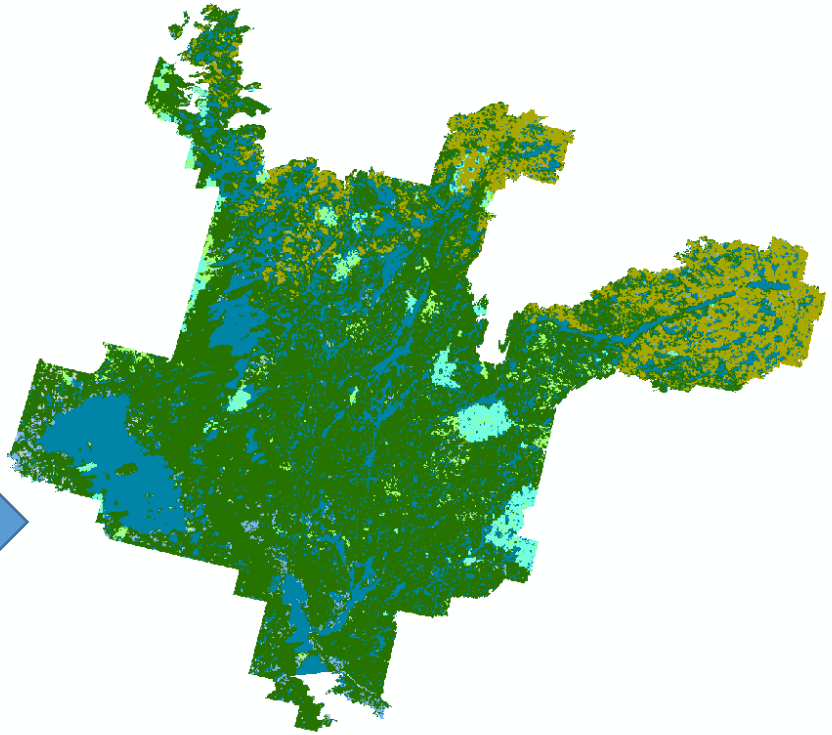
How have wildfires changed land cover in the Tłı̨chǫ land?

From 2000 to 2004

The burned area between 2000 and 2004

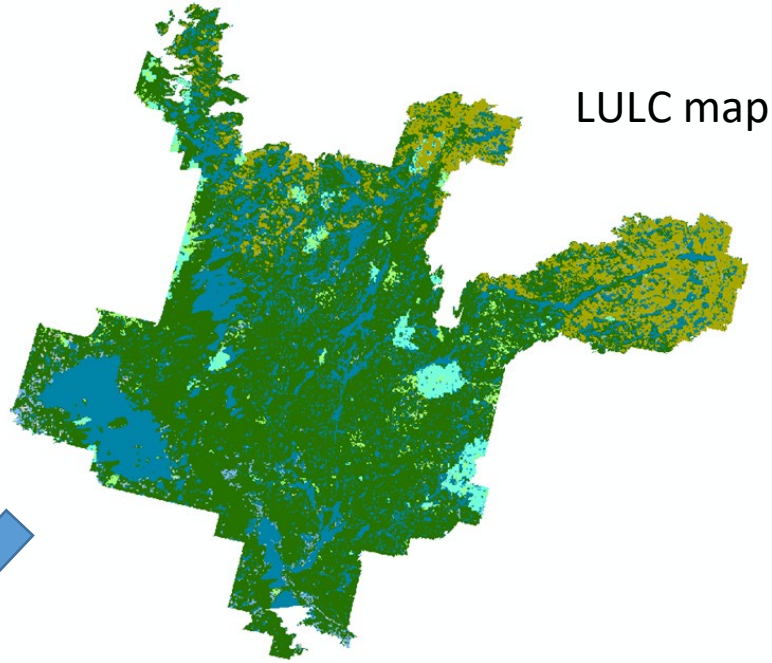


LULC map 2005

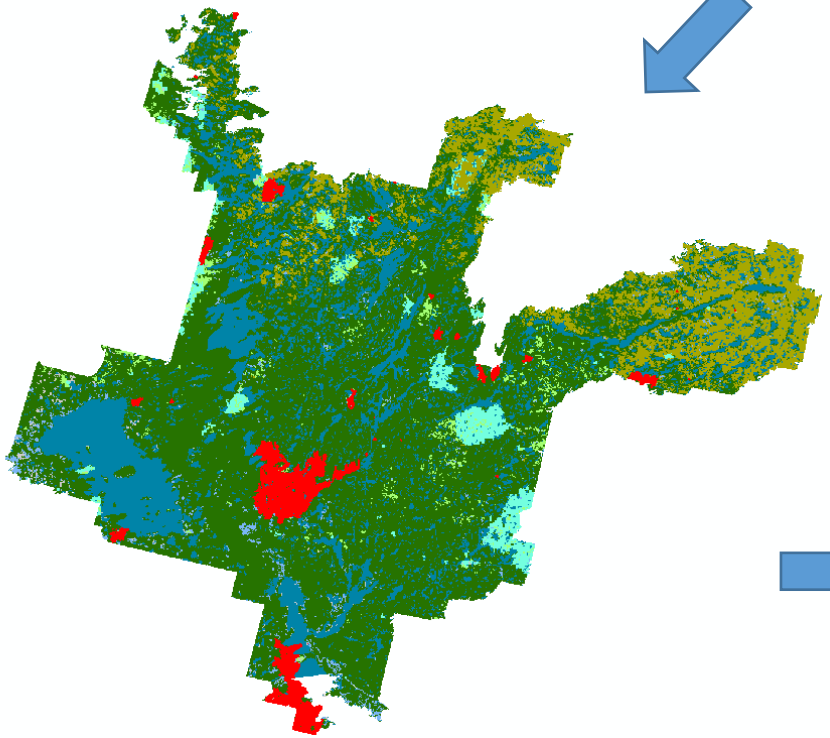


From 2005 to 2009

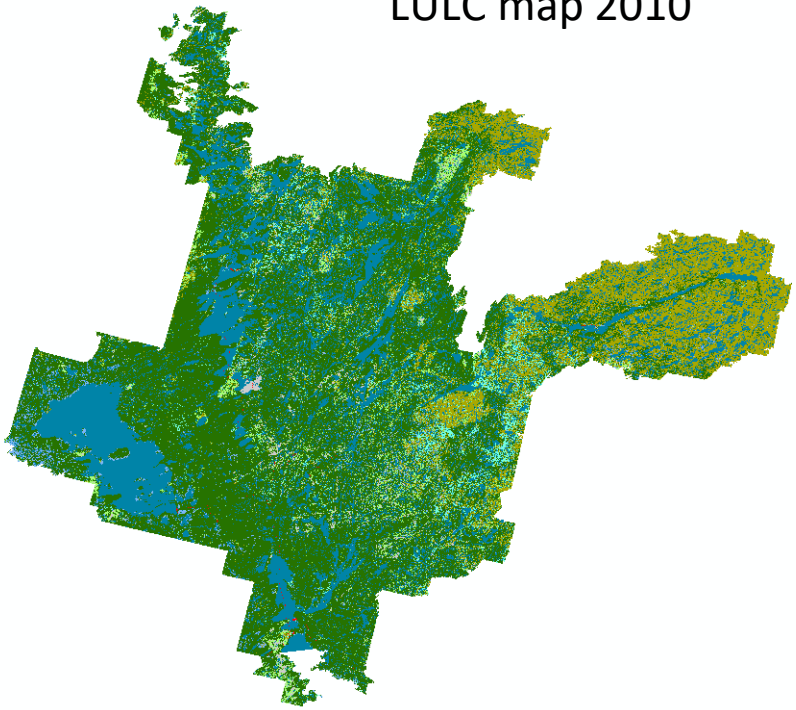
LULC map 2005



The burned area
between 2005 and 2009

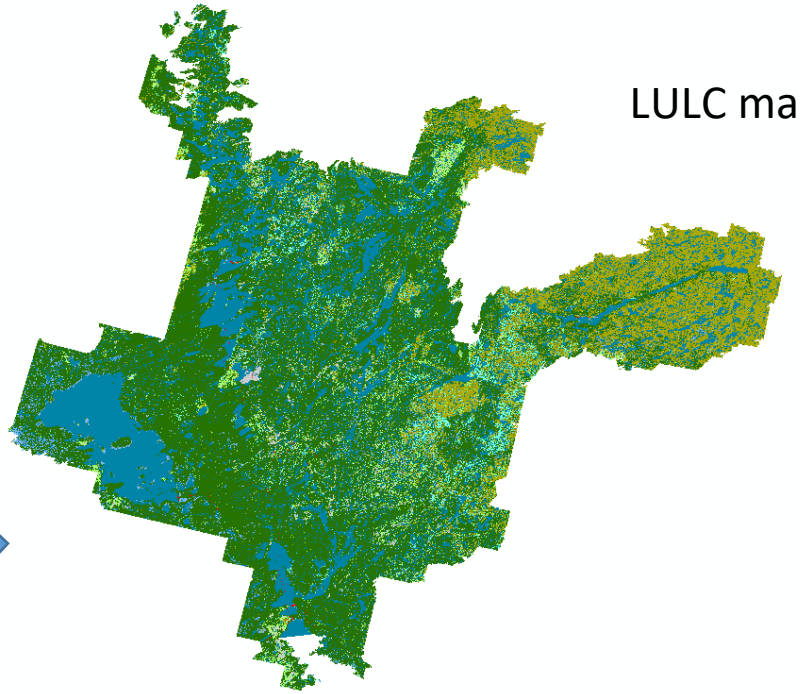


LULC map 2010

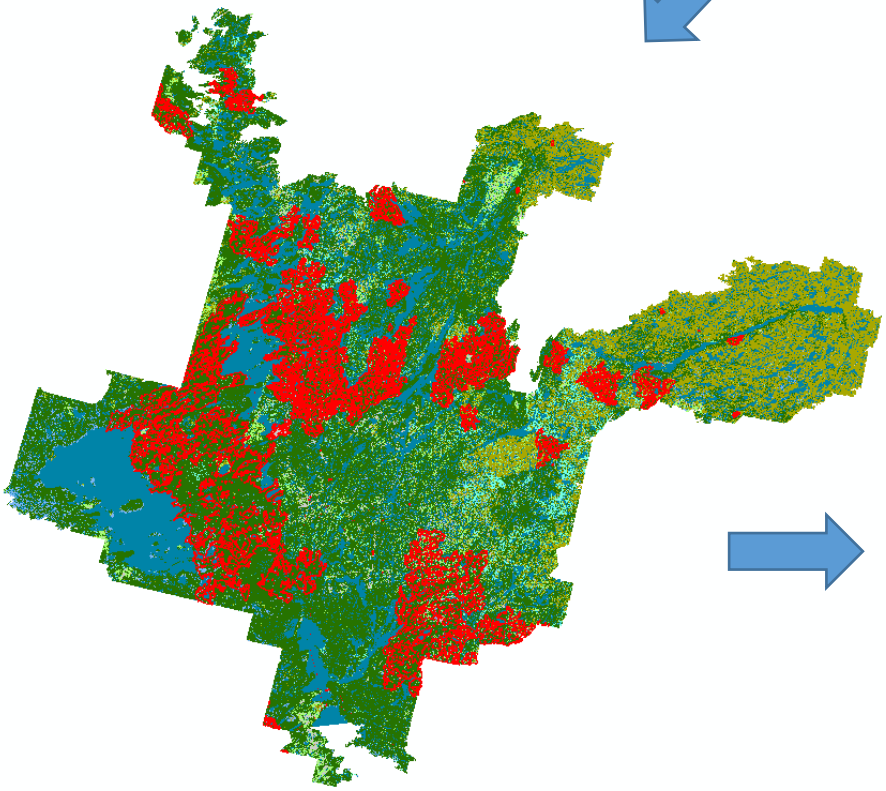


From 2010 to 2014

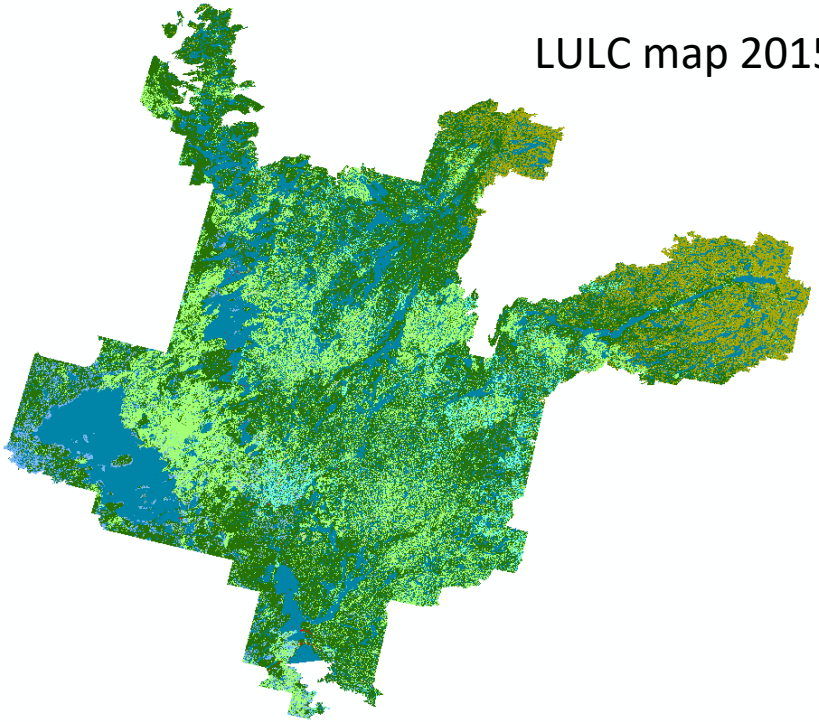
LULC map 2010



The burned area between 2010 and 2014

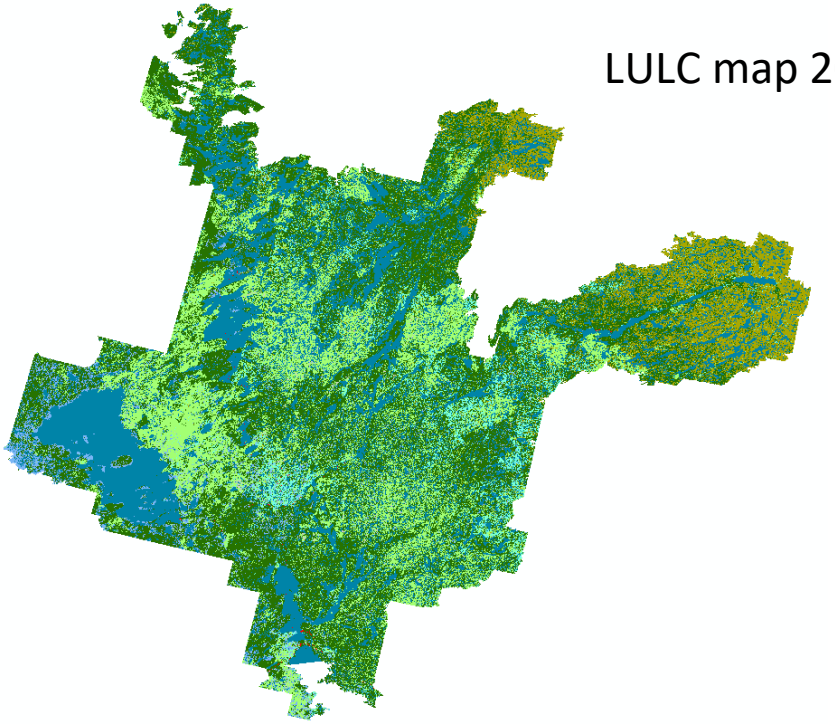


LULC map 2015

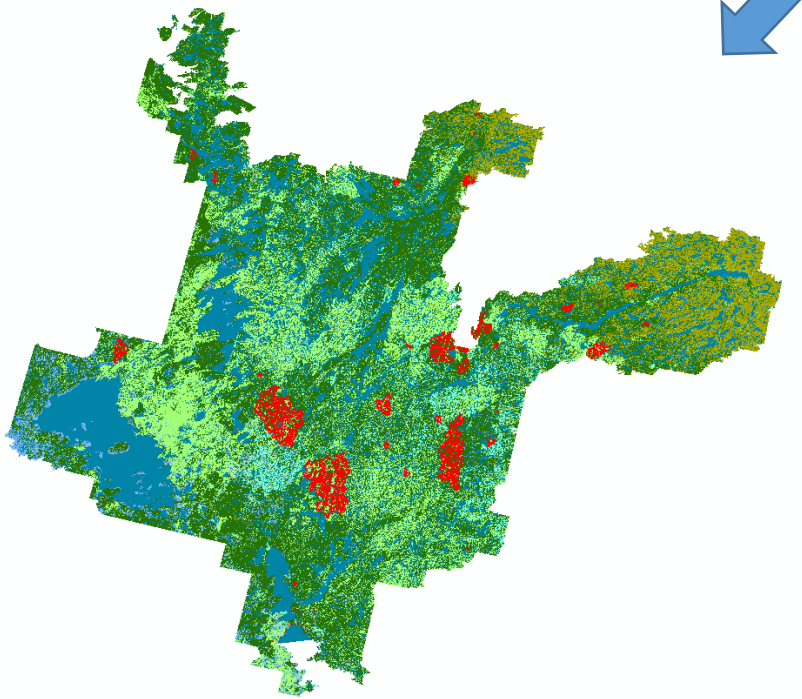


From 2015 to 2019

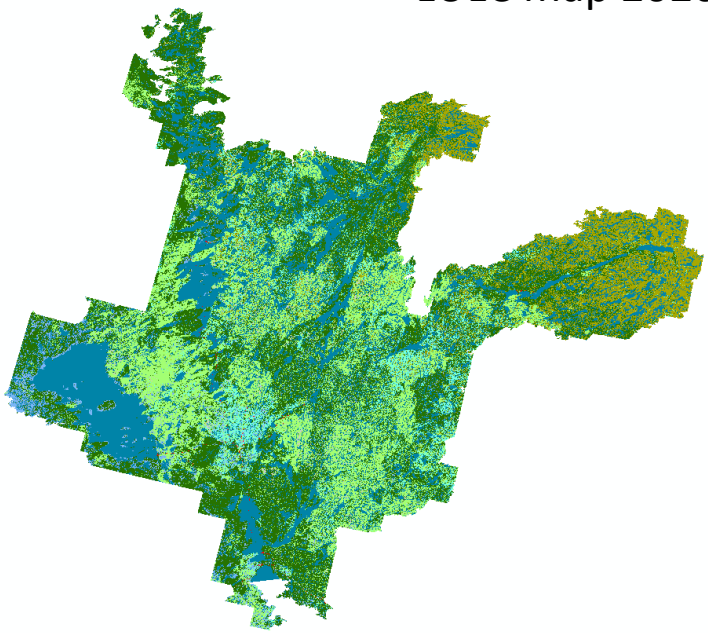
LULC map 2015



The burned area
between 2015 and 2019

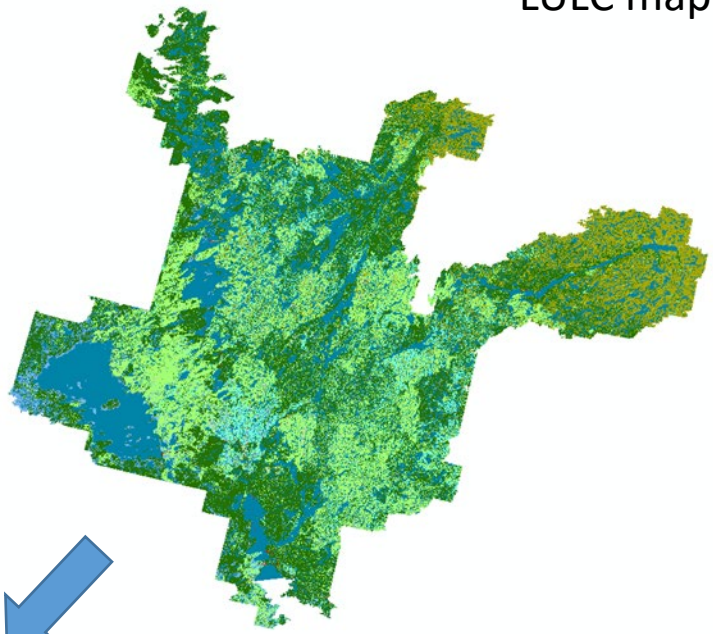


LULC map 2020

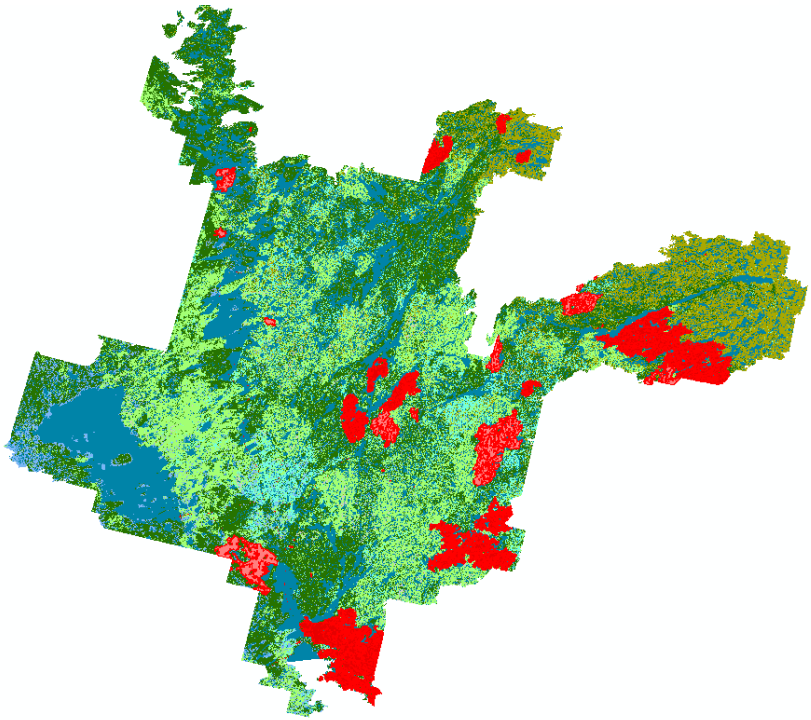


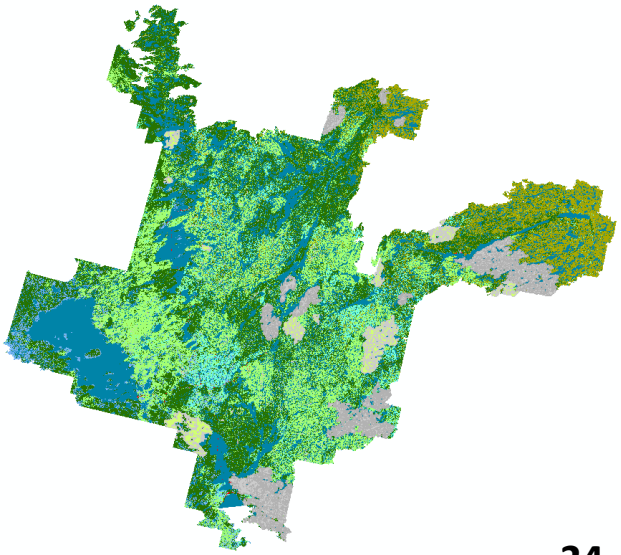
From 2020 to 2023

LULC map 2020

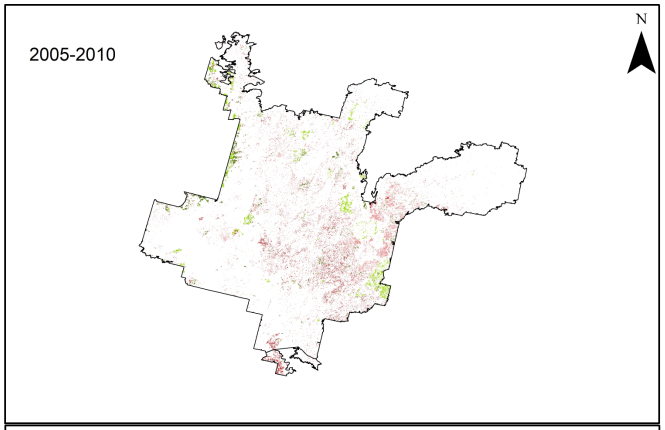


The burned area between 2020 and 2023

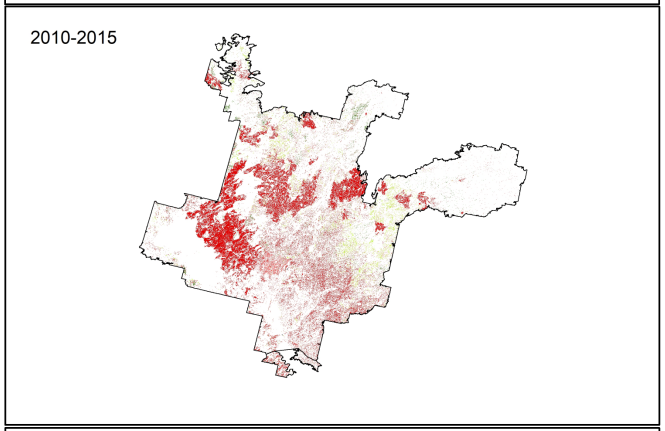




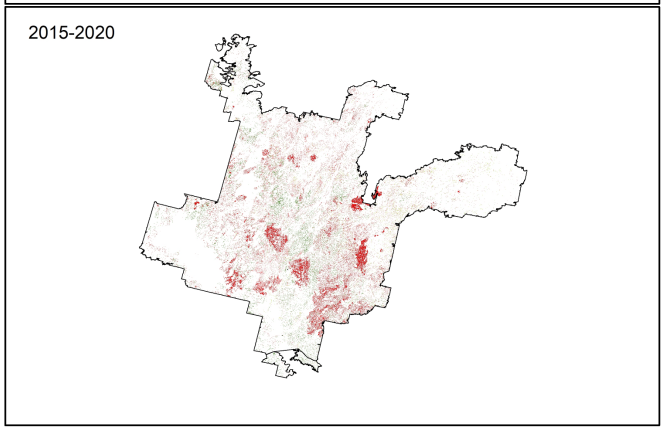
The regenerative capacity of the burned forest area in Tłı̨chǫ land



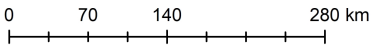
Land cover change	Area (ha)	%
Forest to Shrubland (loss)	83752	3.5
Shrubland to Forest (gain)	41949	2.0
	-41803	-1.5
Forest to Grassland (loss)	72634	3.0
Grassland to Forest (gain)	29056	1.4
	-43578	-1.6



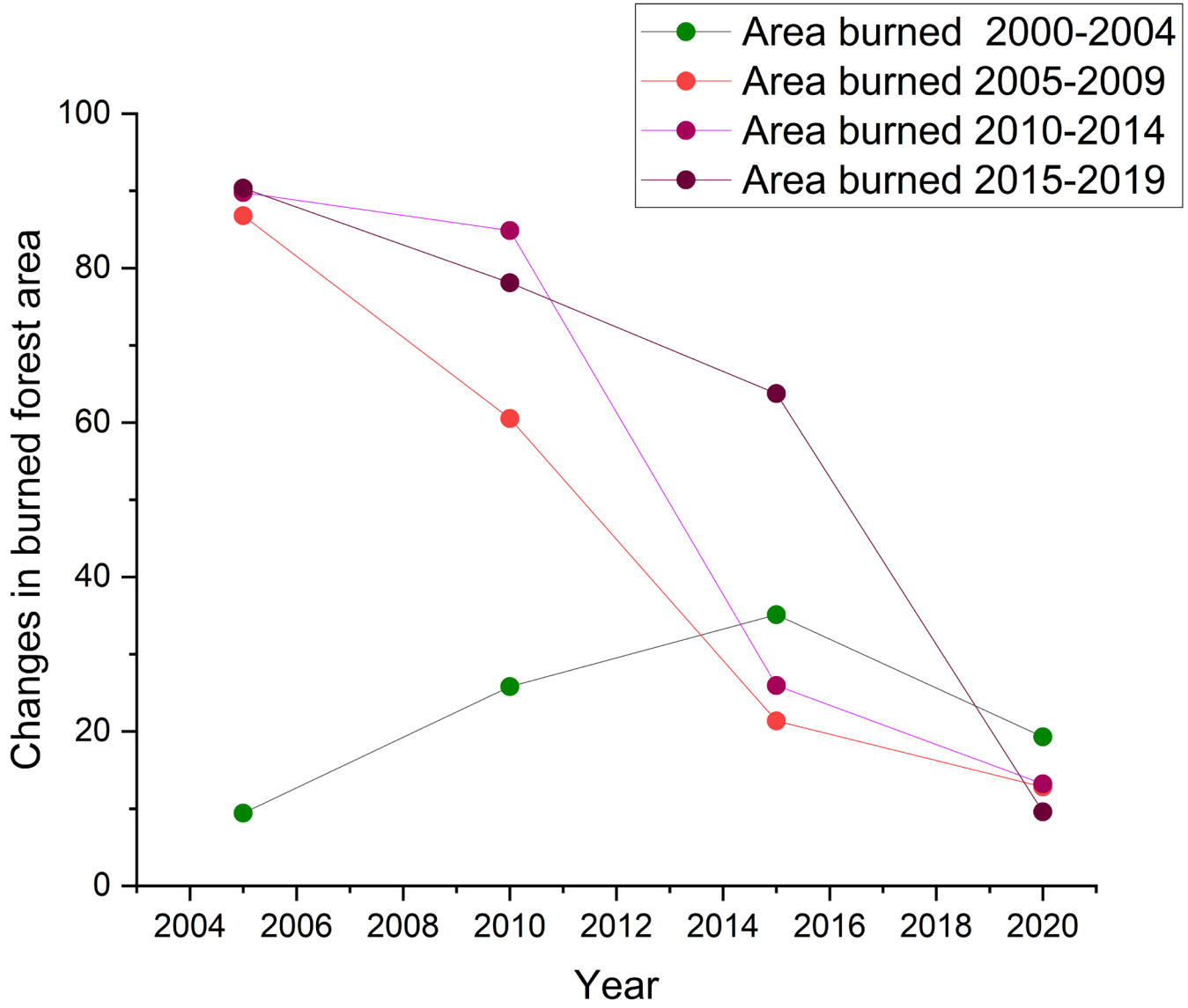
Land cover change	Area (ha)	%
Forest to Shrubland (loss)	71491	3.5
Shrubland to Forest (gain)	43755	2.8
	-27735	-0.6
Forest to Grassland (loss)	525582	25.5
Grassland to Forest (gain)	26916	1.7
	-498666	-23.7



Land cover change	Area (ha)	%
Forest to Shrubland (loss)	78814	5.1
Shrubland to Forest (gain)	14200	1.1
	-64614	-4.0
Forest to Grassland (loss)	189886	12.3
Grassland to Forest (gain)	71985	5.6
	-117901	-6.8



The regenerative capacity of the burned forest area in Tłı̨chǫ land

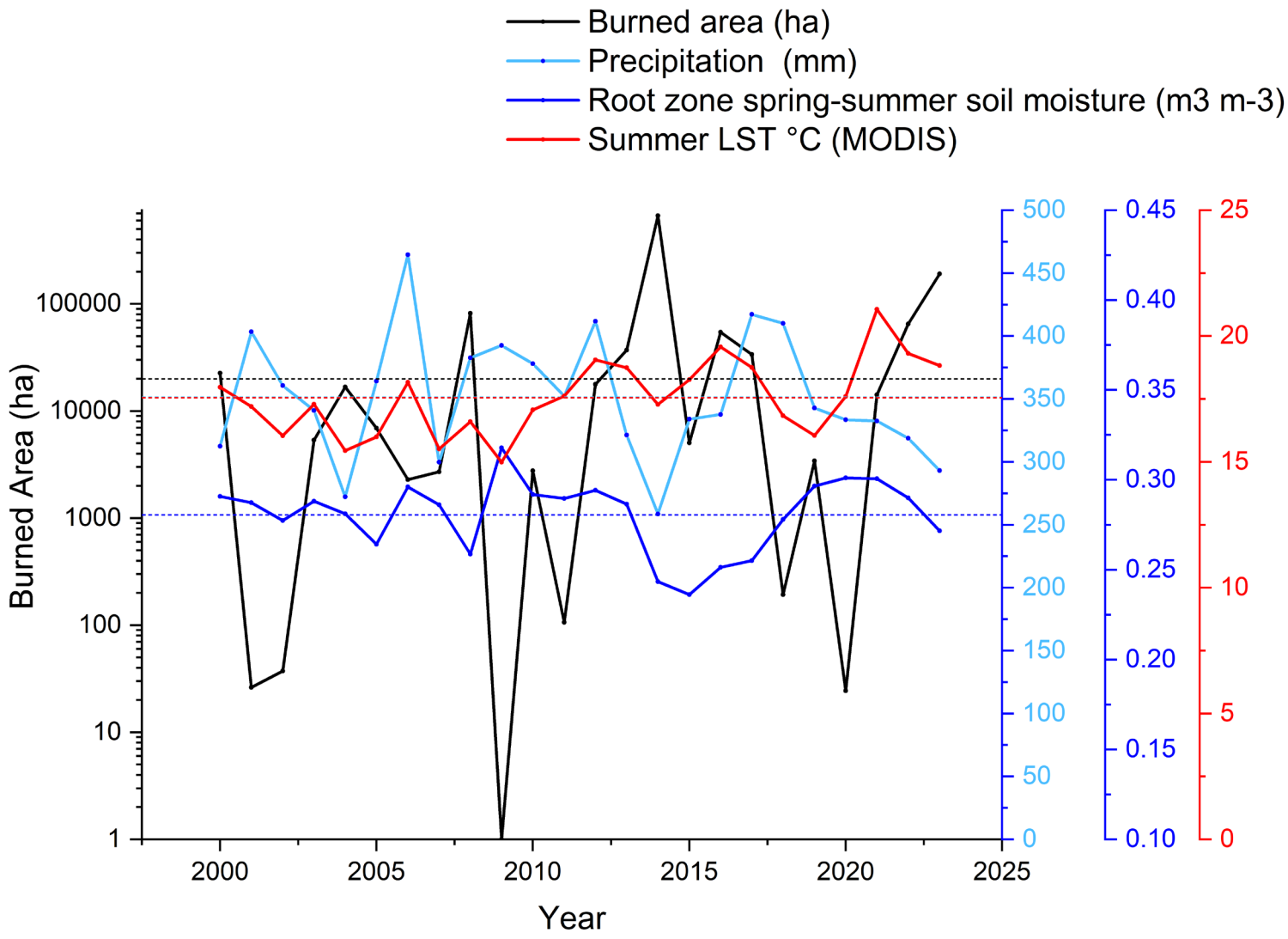


Q4) Is there any relationship between land surface temperature, soil moisture level (dryness), precipitation, snow depth and burn severity

We analyzed the weather and climate variables

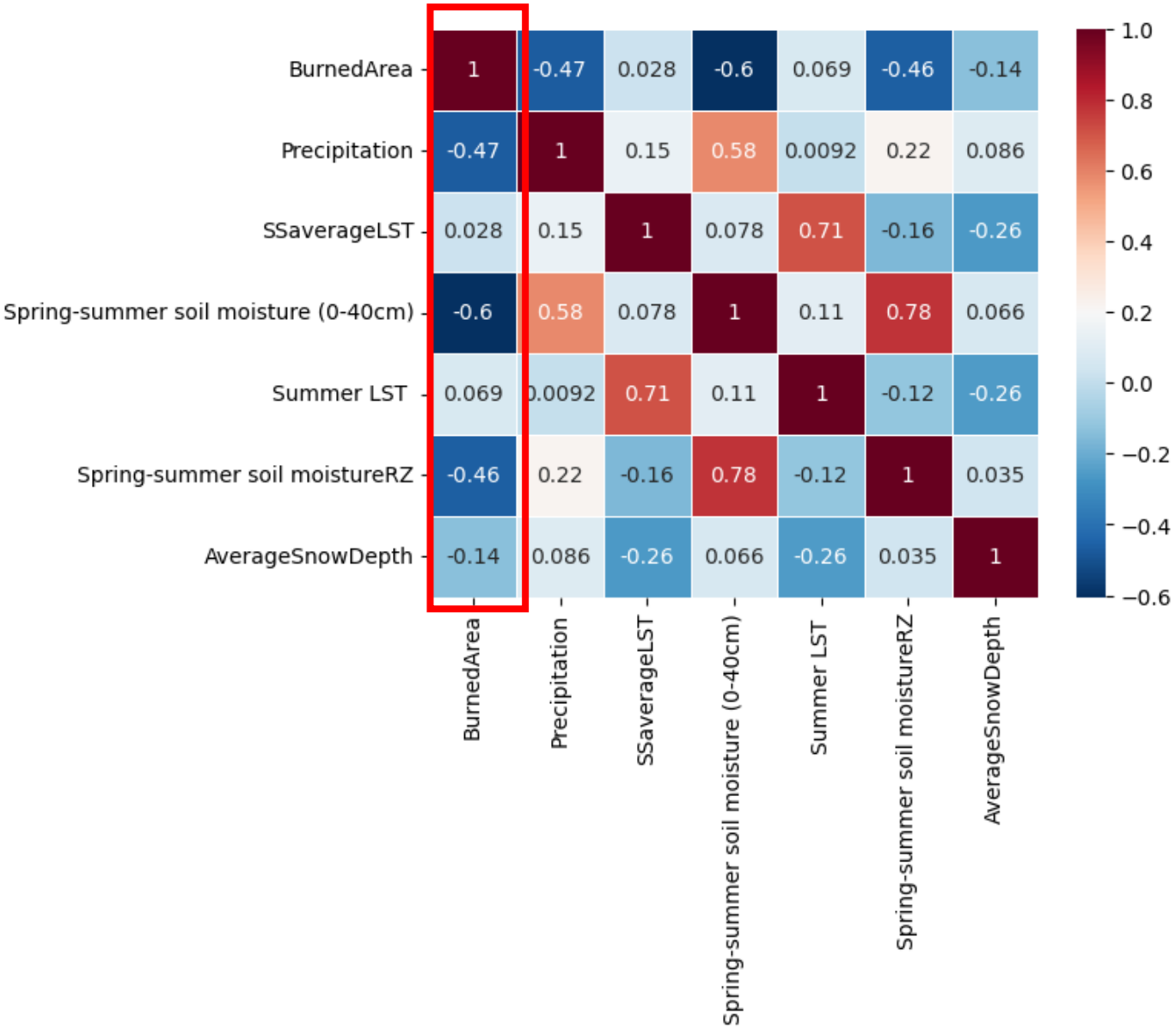
- Surface temperature
- Precipitation, snow depth
- Soil moisture

Effect of weather and climate variables on wildfire intensity

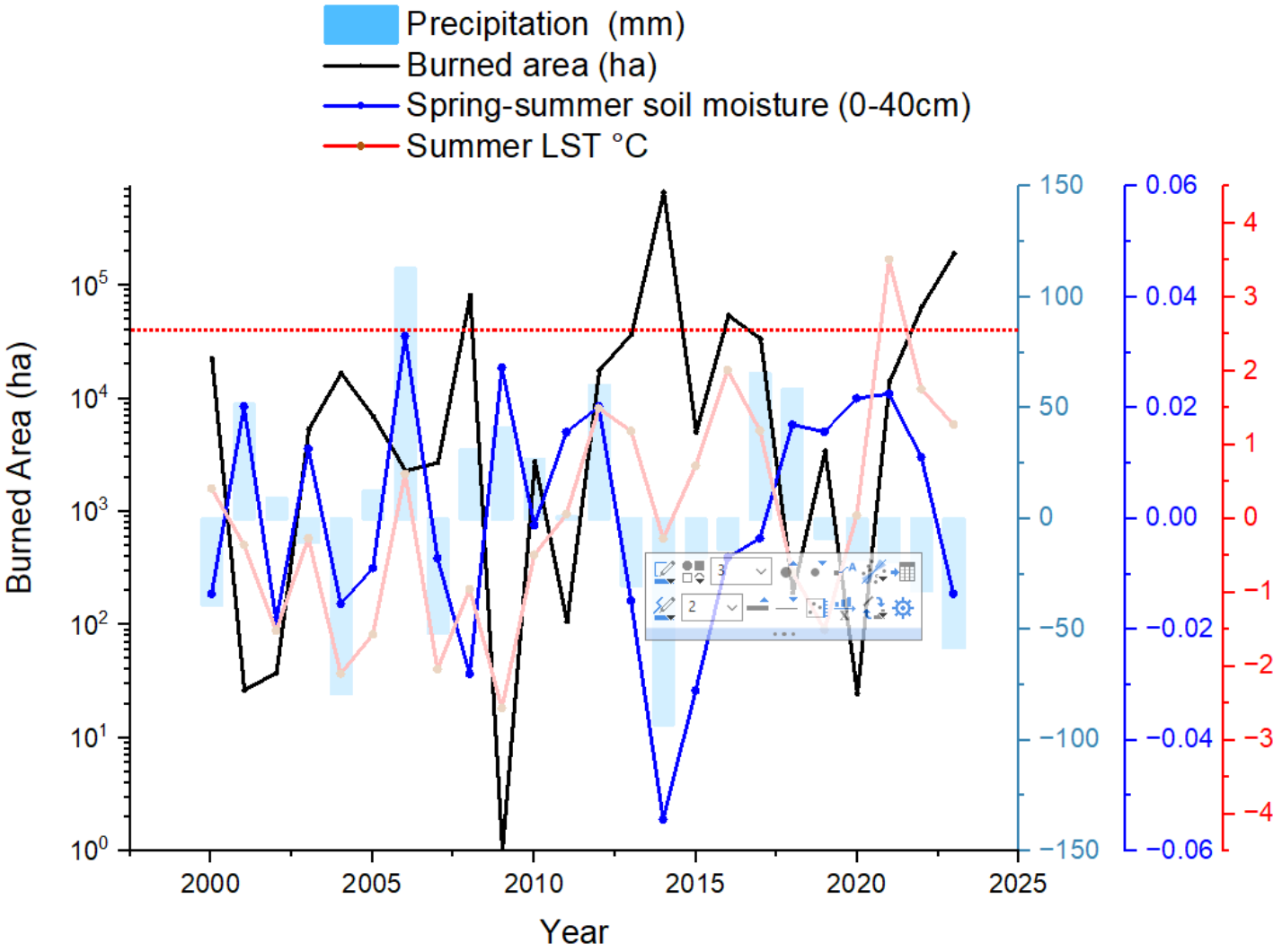


Dash lines indicate the average values of each variable

Relationship between burned area, and weather and climate variables

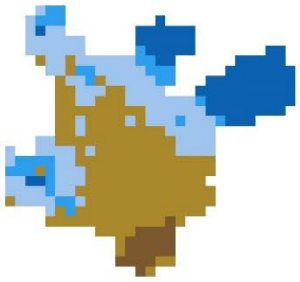


Spring-summer soil moisture in the 0-40 cm layer is mostly correlated with the burned severity

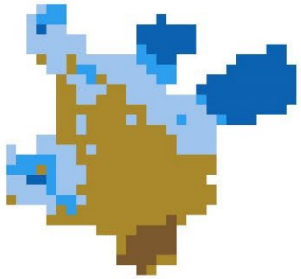


Red dashed line indicates the years that burned areas > 10,000 ha

Soil Moisture Maps 2023

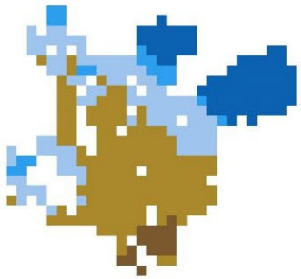


January 2023

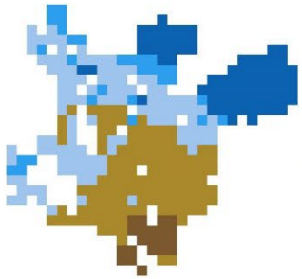


February 2023

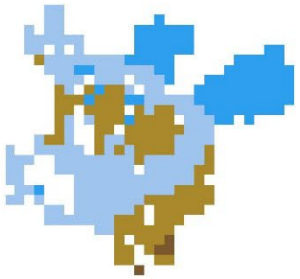
March 2023



April 2023



May 2023



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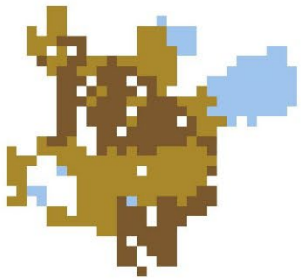

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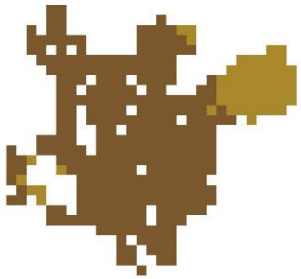

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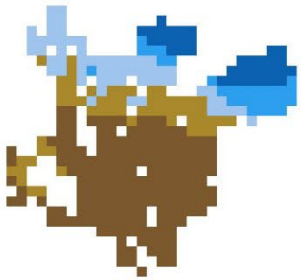

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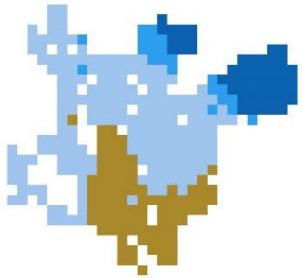
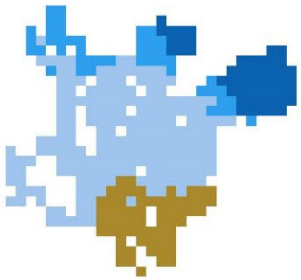


October 2023

November 2023



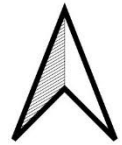
December 2023

Legend

Soil Moisture

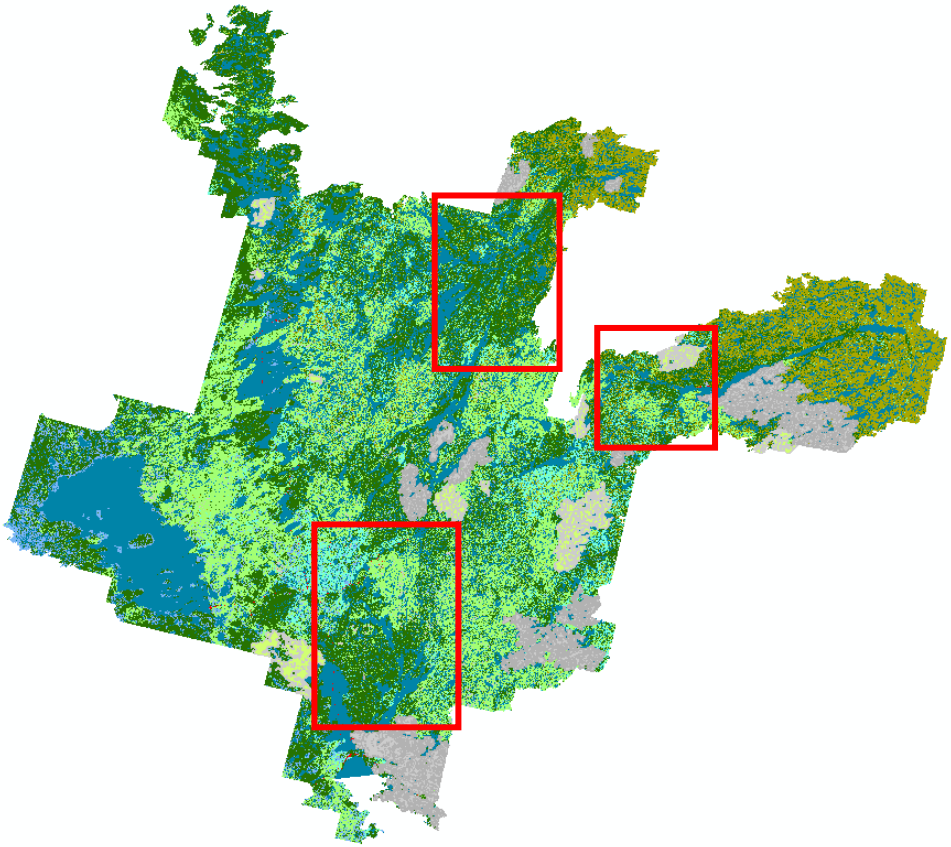
10-40 cm (m3/m3)

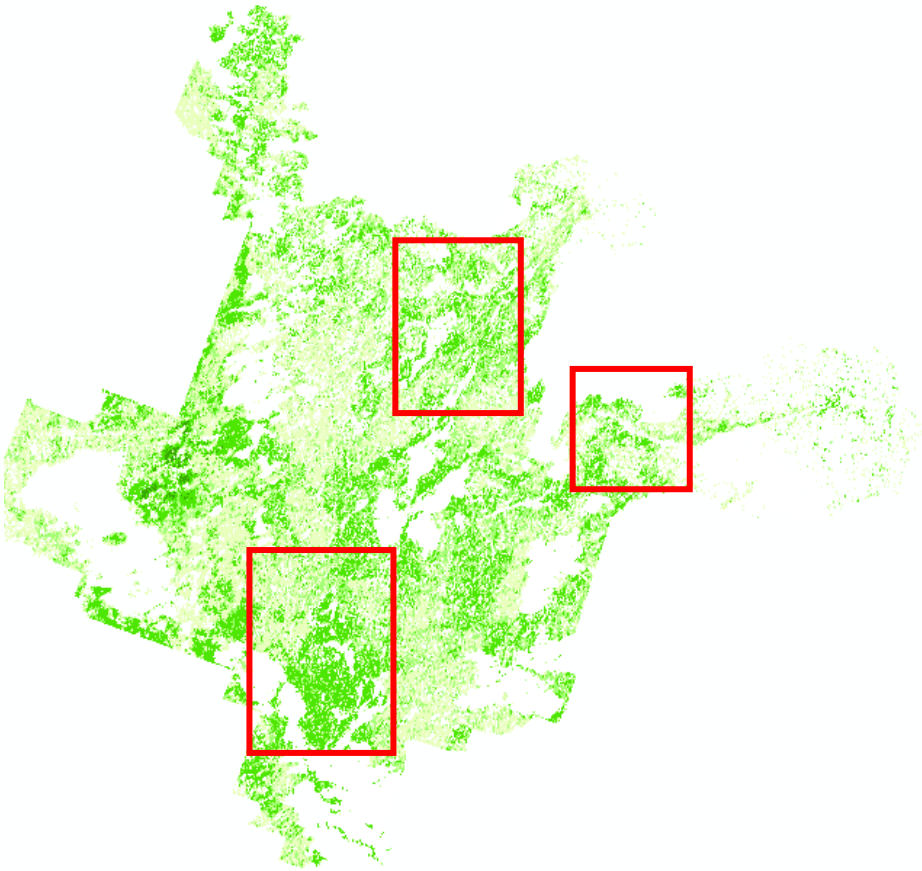
- <= 0.28
- 0.28 - 0.31
- 0.31 - 0.34
- 0.34 - 0.37
- > 0.37



0 50 100 km

Are there any risk areas for wildfires (depending soil moisture, biomass content and land cover type)?





Q5) How can indigenous knowledge be used to reduce the risks linked with wildfire?

We need extensive consultation from Tlicho communities

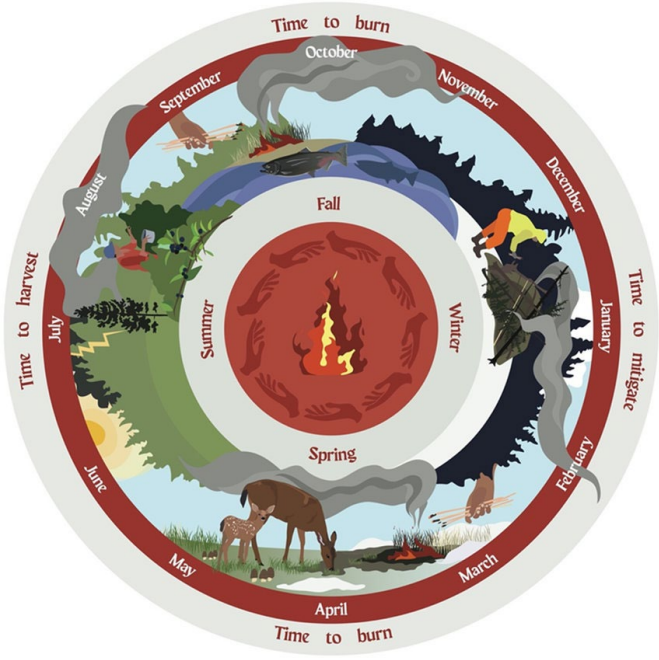
Literature Review on Indigenous Knowledge in Wildfire Management-Cultural Burning

- Indigenous fire management is bouncing back as a way of managing wildfire risks (Nikolakis et al., 2020).
- Goals of indigenous fire management can focus on spheres like reinforcing cultural connection and well-being, restoring health of the land, and considering traditional laws (Nikolakis et al., 2020).
- For wildfire management one of the prime activities is managing fuel load/vegetation load. This can be related with indigenous burning practices.
- A Roadmap for Implementing the Canadian Wildland Fire Strategy: Action Plan 2021–2026 focuses on Recognizing Indigenous Knowledge.

Indigenous Knowledge in Wildfire Management-Cultural Burning

Cultural burning	Prescribed fire
Indigenous-led	Agency driven
Cultural objectives	Hazard reduction or ecological objectives
Indigenous knowledge-driven • when to burn • how to burn	Western science knowledge-driven • when to burn • how to burn
Primarily slow, cool burns • "fires we can walk beside"	• Fire intensity varies depending on objectives
Family-centered	• Parks Canada follows the Incident Command System structure
Traditional fire ignition methods	Use of accelerants and specialised tools • Gasoline/diesel mixtures • Drip torches, heli-torches, etc.

Seasonal Calendar



Month	Observations regarding Fire Management	Bio-cultural Indicators (Species, climate, etc.)	Burning Practices	Other Observations
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

Thank you