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Flint Hills Ecoregion Fire Emissions
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Kansas
Department of Health and Environment
Division of Environment
AD ASTRA PER ASPERA

What are the Flint Hills?

Photo Source: KDHE

- Covering 6.2 million acres which has largely remained native tallgrass prairie

- Undulating hills with limestone, chert (Flint) and shale outcroppings and shallow soils

- Primarily rangeland with extensive cattle grazing

- Largest remaining intact tallgrass prairie in the world (25th largest intact grassland in the world)[1]

Why are Flint Hills important ecologically?

- Only ~4% of the original tallgrass prairie remains[2]

- Home to diverse grasses and forbs,
  and home to several unique animal species

- Under intense pressure –
  North America's most endangered ecosystem[3]
  - Invasive species
  - Woody species
  - Agricultural practices
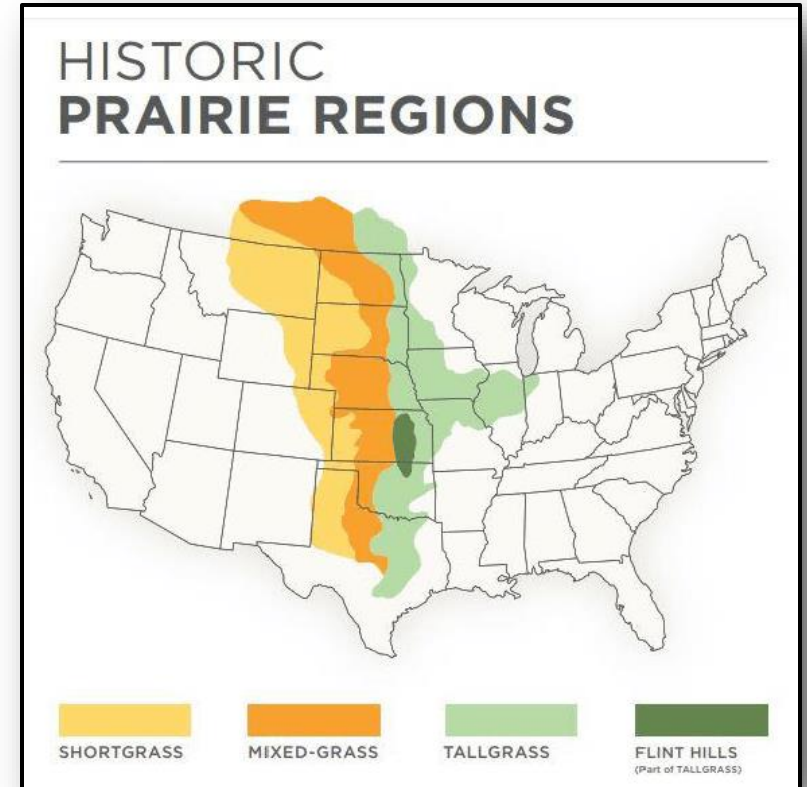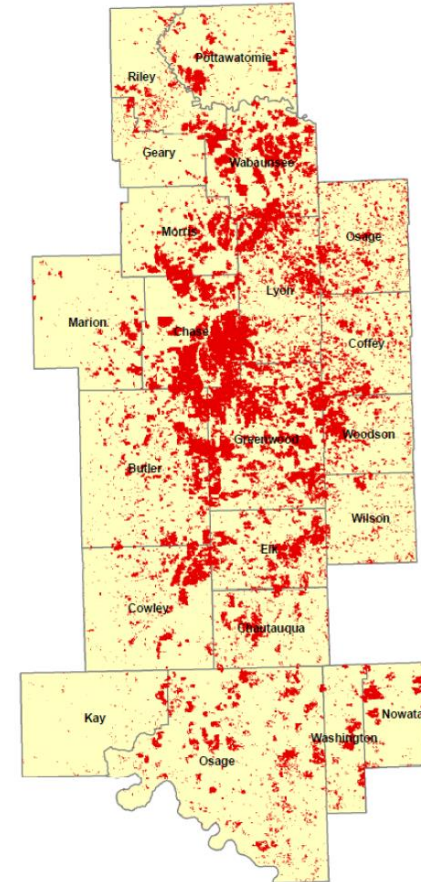 - Land fragmentation

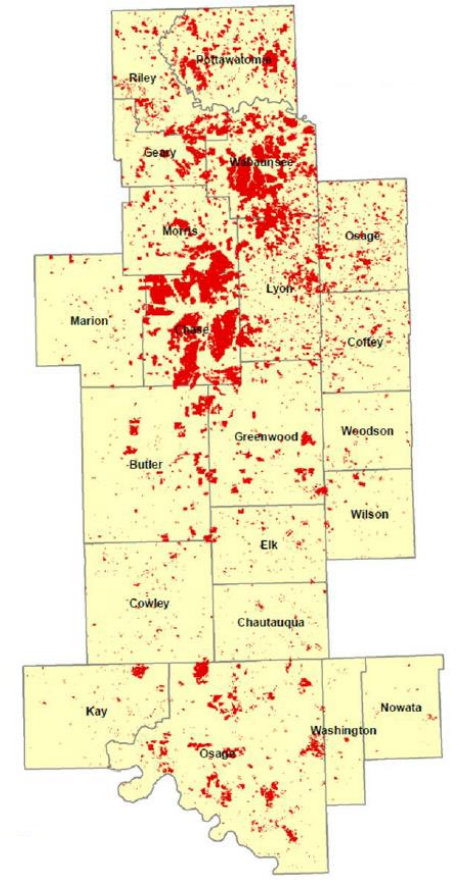Image courtesy Flint Hills Discovery Center

Tracking the Acres Burned

- MODIS Satellite analysis
  - Surface reflectance layers

- Method originally developed by Kansas State University and adopted or continued by KDHE[4]

- Research shows it is improved over default MODIS Burned Area Product and other methods[5]
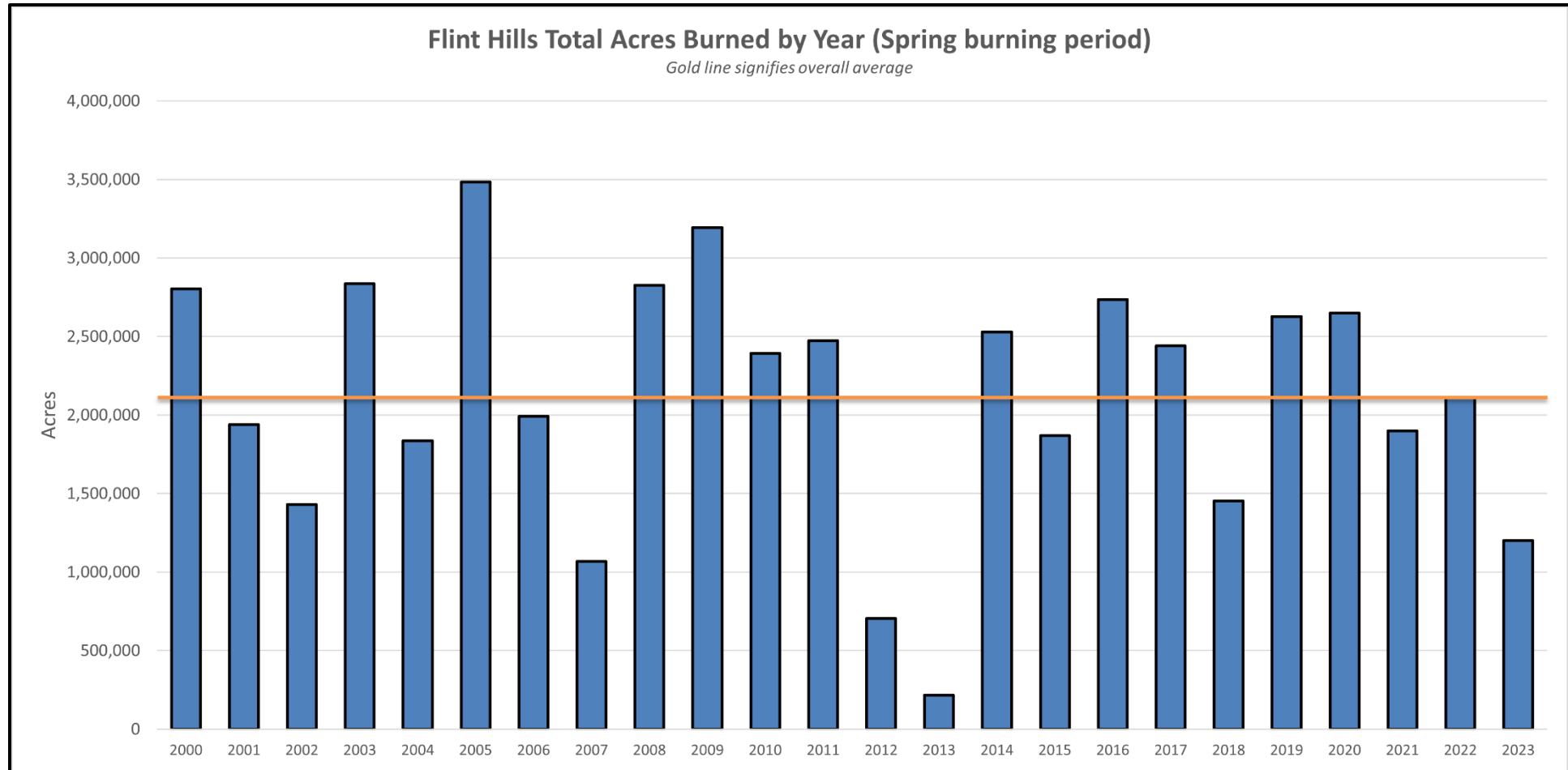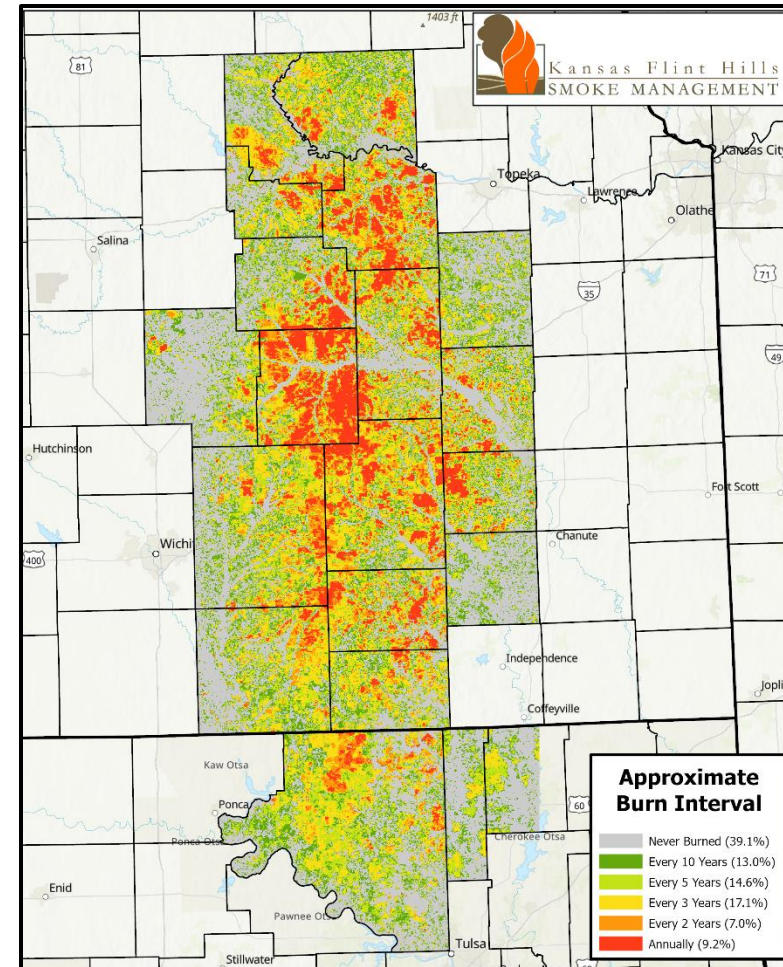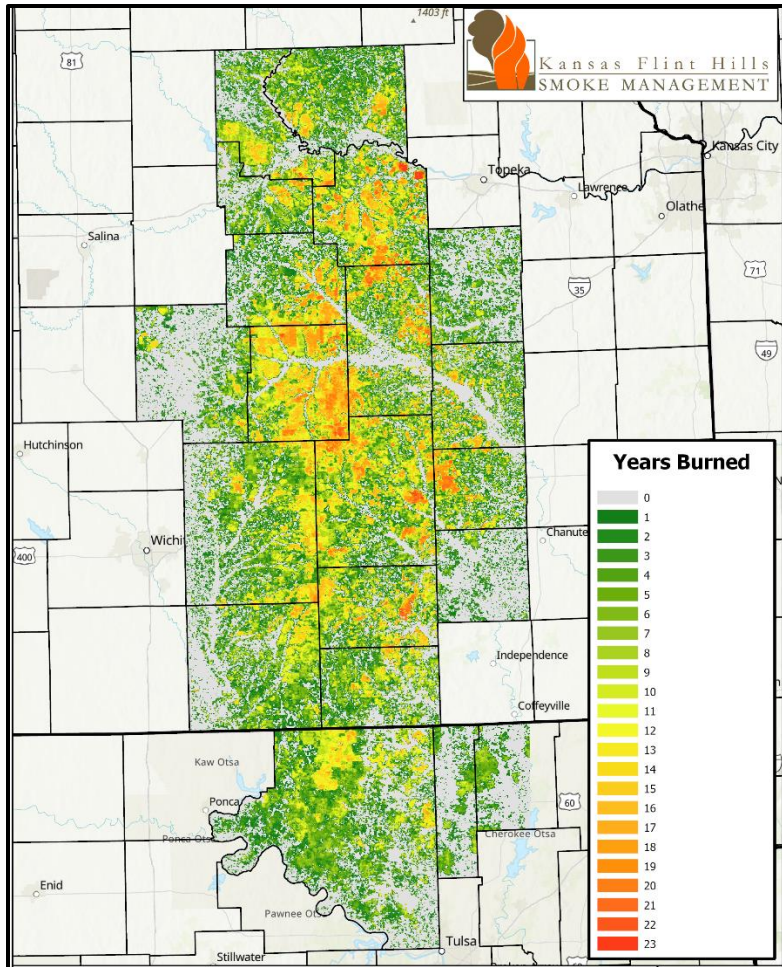
2022
2.1 Million

2023
1.2 Million

Tracking the Acres Burned

Flint Hills Total Acres Burned by Year (Spring burning period)
Gold line signifies overall average

Tracking the Acres Burned

Why are the fire emissions relevant?

- Flint Hills account for 22% (~2.6 of 12.1 million acres) of prescribed fire acres in 2020 National Emissions Inventory (NEI)[6]

Pollutant	Emission Tons (Flint Hills)	Percentage of Prescribed Fire Emissions Nationally
PM2.5	53,898	7%
PM10	56,092	6%
Carbon Monoxide	273,724	3%
Nitrogen Oxides	15,002	10%
Ammonia	3,881	3%
Sulphur Dioxide	5,358	7%
Volatile Organic Compounds	92,018	4%

Flint Hills Ecoregion Fire Emissions

Determining Relevant Emission Factors

- KDHE and Kansas State University research effort[7]
- Measuring smoke emissions in Flint Hills using unmanned aircraft systems
  - Used data from 42 flights across four separate prescribed fires
  - Carbon mass balance method

Pollutant	KDHE/KSU Study Emission Factor (g/kg)	SERA Rx Grassland [8] Emission Factor (g/kg)
PM2.5	11.3 ±10.8	15.8 ±9.8
Carbon Dioxide	1569 ±28	1618 ±176
Nitrogen Oxide	1.4 ±0.9	3.5 ±0.33
Volatile Organic Compounds	4.5 ±3.5	10.3 ±6.8
Methane	6.8 ±4.3	2.5 ±1.4

Determining Relevant Emission Factors

Photo Source: KDHE

Photo Source: KDHE

Determining Relevant Emission Factors

- Compared headfire vs backfire emission factors
  - Headfires resulted in higher EF for PM2.5
  - Backfires had higher EF for NOx and VOC

- Moisture content in Vegetation
  - Highest PM2.5 EF in highest vegetation moisture content

- Compared meteorological conditions and ozone generation
  - Higher ambient air temperature and absolute humidity resulted in higher ozone generation

Photo Source: KDHE

Determining Relevant Emission Factors

- U.S. EPA Research using 1-hectare plots at Konza Prairie Biological Station (KPBS)[9]
    - Unmanned aerial system, aerostat, and ground-based research
    - Seasonality of burns and impact on emission factors

- U.S. EPA Research of Volatile Organic Compound (VOC) emissions[10]

Pollutant	EPA KPBS Research Emission Factor (g/kg)	EPA VOC Research Emission Factor (g/kg)
PM2.5	17.1 ±12.9	
Carbon Dioxide	1692 ±59	1612
Nitrogen Oxide	2.1 ±1.3	
VOC		5.6 ±0.9

Determining Relevant Emission Factors

Photo Source: KDHE

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Summary of Flint Hills Fires

- Emission factors and emissions vital for this single area with ~20% of prescribed fire acres and up to 10% of pollutant emissions for the entire country

- Understanding methods and thresholds that could reduce emissions

- Specific emission factors showing uniqueness of vegetation
(Flint Hills vs general grassland)

  - Especially important with increased call for more prescribed fire

  - And potential lowering of National Ambient Air Quality Standards (NAAQS)

Future Work

- Expansion of satellite monitoring
  - Fall season (Aug-Oct) being completed
  - Larger expanse of the state

- More analysis on Emission Factors and conditions
  - Meteorological (e.g., temperature, humidity)
  - Vegetation (i.e., moisture content)

- Further refinement of emission factors
  - Smoldering fuels (i.e., cow patties)
  - Firing techniques

Photo Source: KDHE

References

[1] Scholtz, R., & Twidwell, D. (2022). The last continuous grasslands on Earth: Identification and conservation importance. Conservation Science and Practice, 4(3), e626.

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[7] Liu, Z., Baldwin, C., Watson, D., Prentice, J., Balthazor, T., & Haque, M. A. (2023). Measuring smoke emissions from prescribed rangeland burning in the Flint Hills region using unmanned aircraft systems. Journal of the ASABE, *In Publication*.

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[9] Aurell, J., Gullett, B., Grier, G., Holder, A., & George, I. (2023). Seasonal emission factors from rangeland prescribed burns in the Kansas Flint Hills grasslands. Atmospheric Environment, 304, 119769.

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Thank you/Questions

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