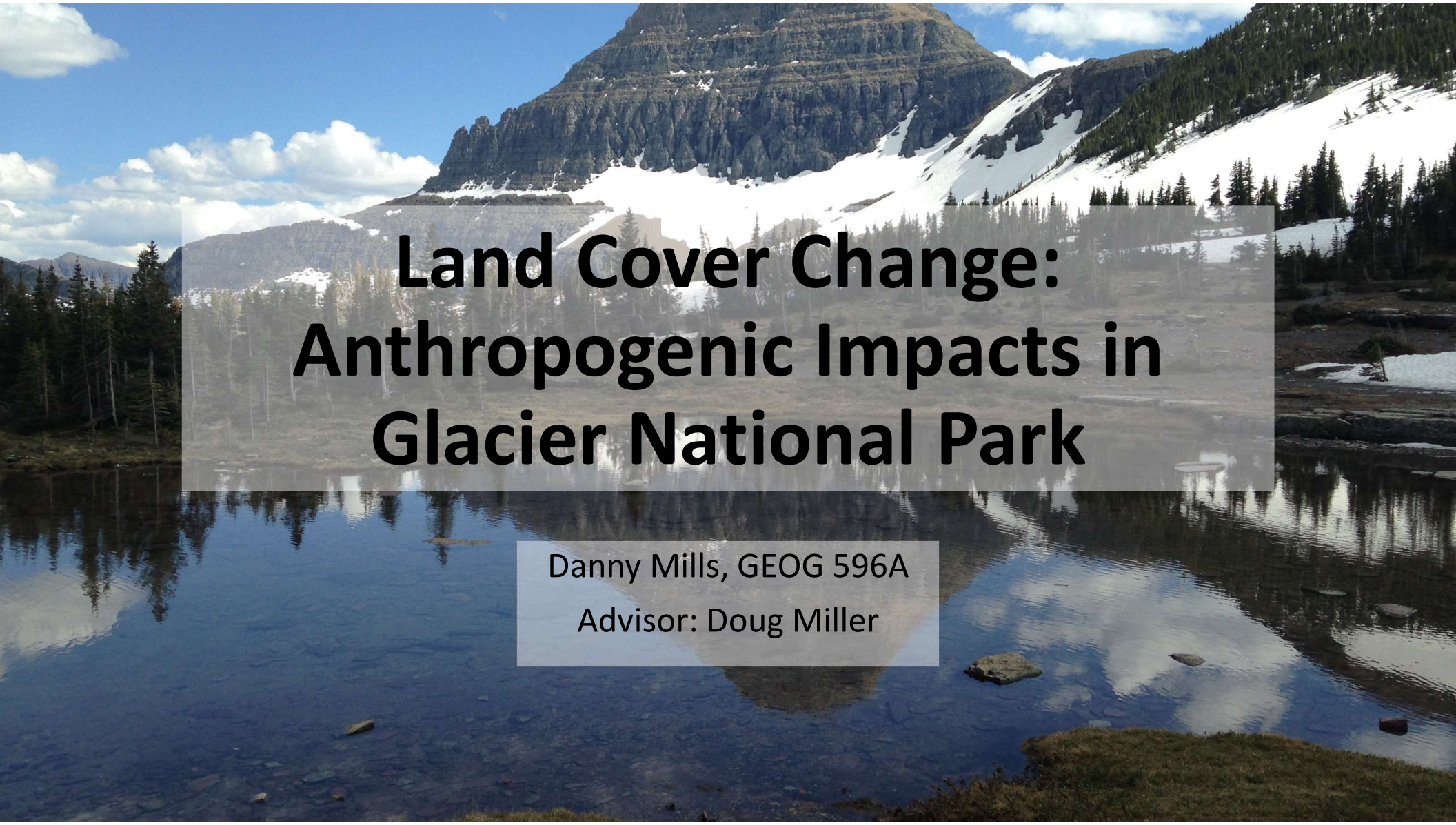


Land Cover Change: Anthropogenic Impacts in Glacier National Park

Danny Mills, GEOG 596A

Advisor: Doug Miller

Overview

- Background
- Goals and Objectives
- Data Resources
- Timeline of Data
- Methodology
- Anticipated Results

Background

- National Park Service mission is to preserve
- Climate change has presented a challenge to maintaining protected park ecosystems
- Anthropogenic factors have played a role in climate change

"The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations" (National Park Service, 2020).

Background

- Increased temperatures causing melting glaciers and decreased population control of destructive insects
- Wildfires due to drought and approach to forest management
- Invasive plant species preventing native plants from growing

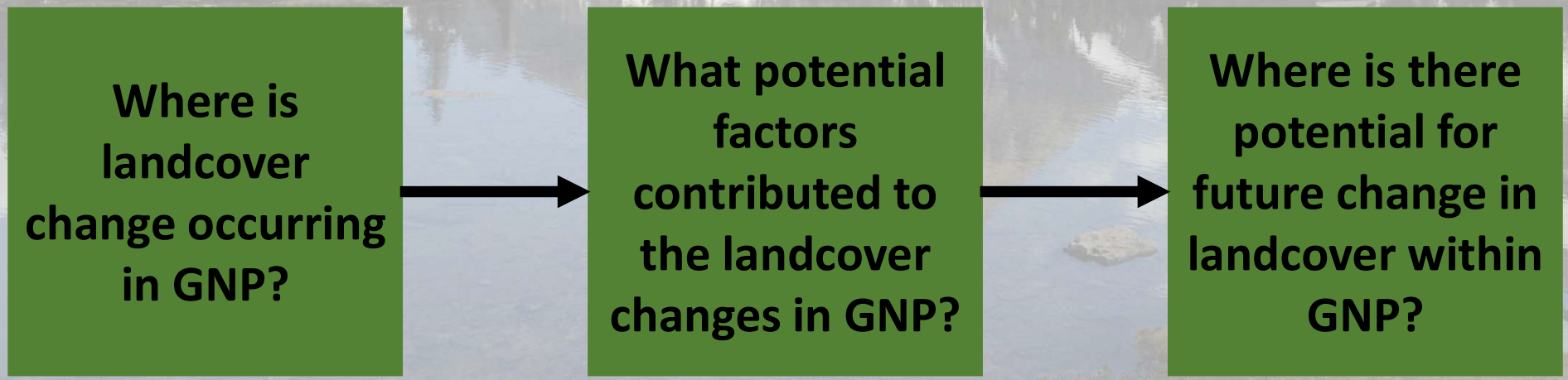
Background

- National Land Cover Dataset change index covering 2001-2016 shows significant change in Glacier National Park

- Comprehensive analysis of factors that caused land cover change within GNP is lacking

Goals and Objectives

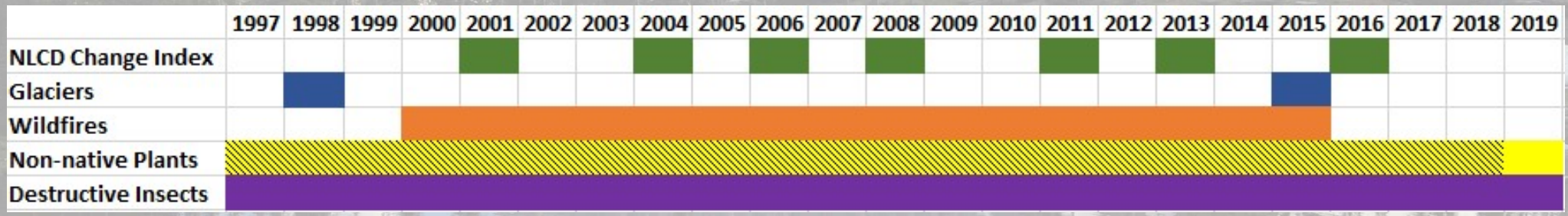
- **Primary goal: Determine possible causes of land cover change in GNP and characterize the areas where change is occurring**
  - **Provide a more comprehensive view of land cover change within GNP**
  - **Locate areas that may be susceptible for future change**



Data Resources

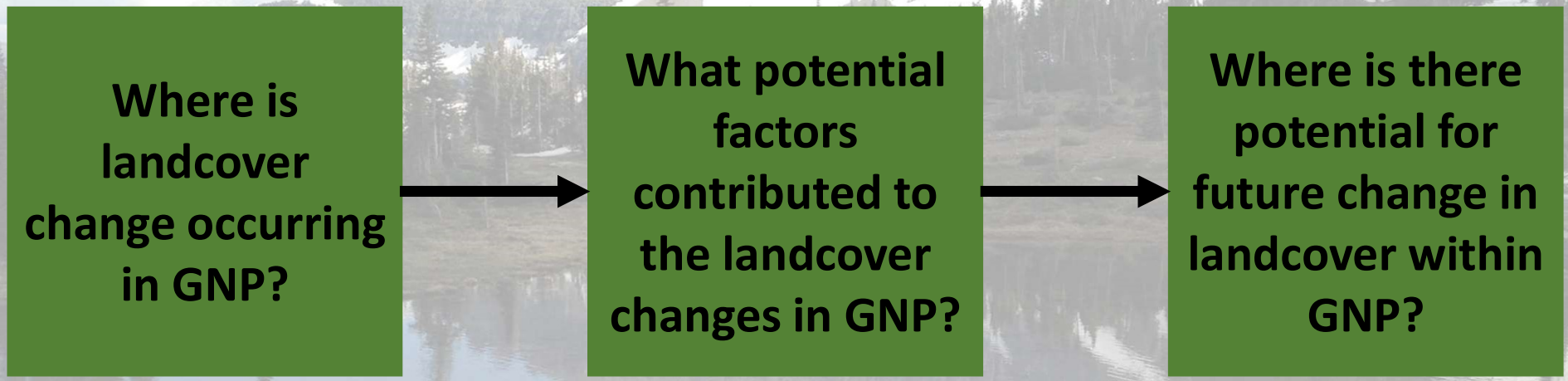
Data	Format	Source
National Land Cover Database Change Index	Raster	U.S. Geologic Survey
Glaciers	Polygons	Northern Rocky Mountain Science Center, U.S. Geologic Survey
Wildfires	Polygons	National Park Service; NPS Fire Management Wildfire History & Glacier National Park Fire Park Atlas
Non-native Invasive Plants	Table	National Park Service, Glacier National Park
Destructive Insects	Polygons	U.S. Forest Service

Timeline of Data



Methodology

Analysis of Land Cover Change Within Glacier National Park from 2001-2016



Bold Indicates data or a layer

Function Indicates GIS operation

Where is landcover change occurring in GNP?

GNP U.S. Boundary

NLCD Change Index 2001-2016

Clip Raster to GNP boundary

NLCD Change Index 2001-2016 within GNP

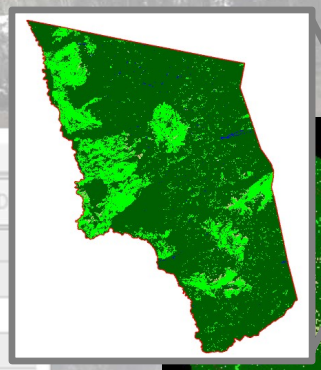
Classes of change

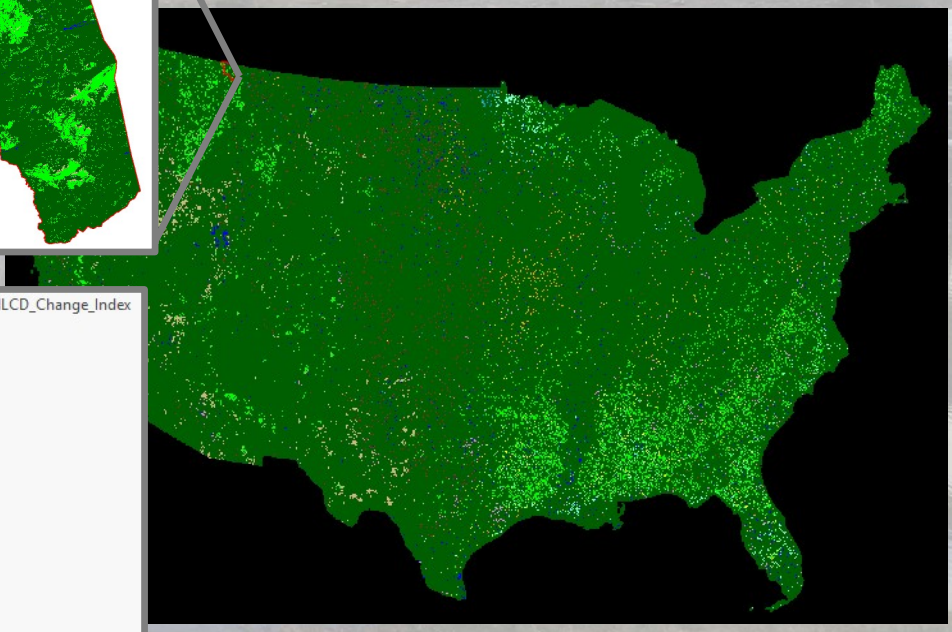
Areas of change

GNP_NLCD_Change_Index

Field: Add Calculate | Selection: Select By Attributes Zoom To Switch Clear

OBJECTID *	Value	Count	Red	Green	Blue	Opacity	NLCD_Chang
2	1	3606103	0	95	0	255	no-change
3	2	12192	0	0	255	255	water change
4	3	58	236	130	236	255	urban change
5	4	44	121	255	210	255	wetland within class change
6	5	100	0	158	222	255	herbacous wetland change
8	7	199	159	40	40	255	cultivated crop change
9	8	407	255	255	0	255	hay/pasture change
10	9	30981	209	181	136	255	persistent grass and shrub change
11	10	7109	192	192	192	255	barren change
12	11	877253	0	255	0	255	forest-theme change
13	12	2	255	0	0	255	woody wetland change





NLCD change index within GNP; classifications with the most change in red

Where is landcover change occurring in GNP?

GNP U.S. Boundary

NLCD 2001

NLCD 2016

Clip Raster to GNP boundary

NLCD classes within GNP in 2001

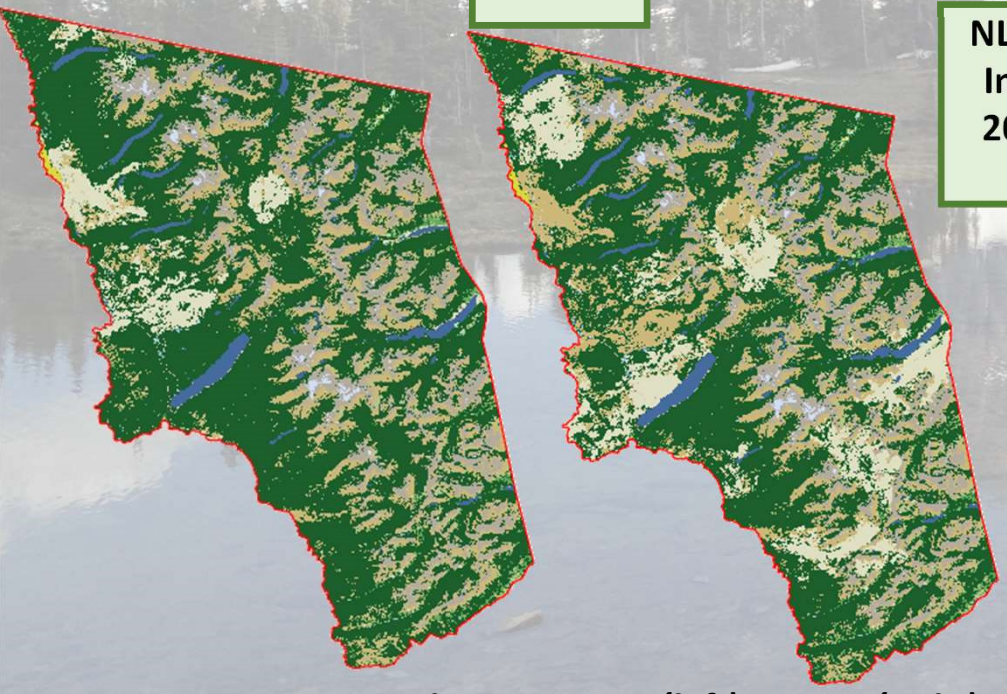
NLCD classes within GNP in 2001

NLCD Change Index 2001-2016 within GNP

Reclassify Values: 0=No change, 1=Change

Raster Calculator: multiply values

Initial & Final NLCD classification 2001-2016



NLCD within GNP 2001 (left) & 2016 (right)

Expected Results and Anticipated Challenges

- Classes of change from the NLCD change Index
- Areas of change (location and percentage)
- Initial NLCD classification in 2001
- Final NLCD classification in 2016
- Remaining land cover
- New land cover

- Broad classification categories generalizing change

What potential factors contributed to the landcover changes in GNP?

GNP U.S. Boundary

Fires 2000s

Fires 2010-2015

Clip to GNP boundary

Fires within GNP 2000-2009

Fires within GNP 2010-2015

Union

Polygon to Raster

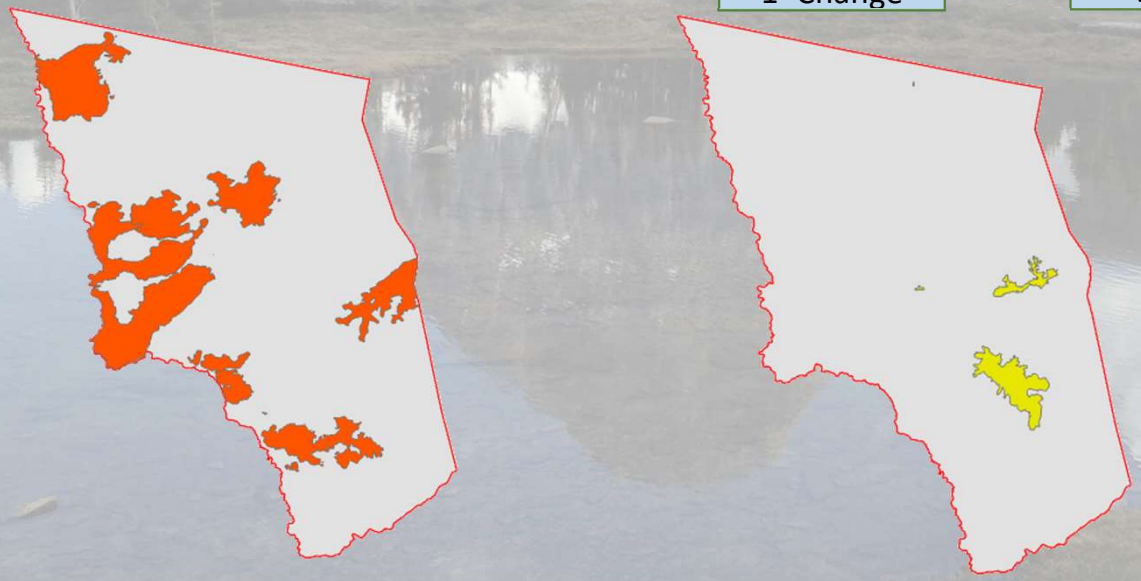
Reclassify Values: 0=No fire, 1=fire

NLCD Change Index 2001-2016

Reclassify Values: 0=No change, 1=Change

Raster Calculator: multiply values

Areas changed where fires occurred



Fires within GNP 2000s (left) & 2010-2015 (right)

Expected Results and Anticipated Challenges

- Areas of the NLCD change index correlated to wildfire
- Percentage of land cover altered by wildfire
- Land cover classifications that changed
- Land cover classifications that resulted

- Inaccurate or loss of data due to conversion from polygon to raster

What potential factors contributed to the landcover changes in GNP?

GNP U.S. Boundary

Glaciers 1998

Glaciers 2015

Clip to GNP boundary

Glaciers within GNP 1998

Glaciers within GNP 2015

Union

Polygon to Raster

Reclassify Values: 0=No glacier, 1=glacier

NLCD Change Index 2001-2016

Reclassify Values: 0=No change, 1=Change

Raster Calculator: multiply values

Areas changed where glacier loss occurred

Glaciers within GNP 1998 (left) & 2015 (right)

Expected Results and Anticipated Challenges

- Areas of the NLCD change index correlated to glacial melting
- Percentage of land cover altered by glacial melting
- Land cover classifications that changed
- Land cover classifications that resulted

- Only examines areas where glaciers are located but does not capture if melting led to an increase in the size of bodies of water
- NLCD change index may not capture change due to resolution
- Inaccurate or loss of data due to conversion from polygon to raster

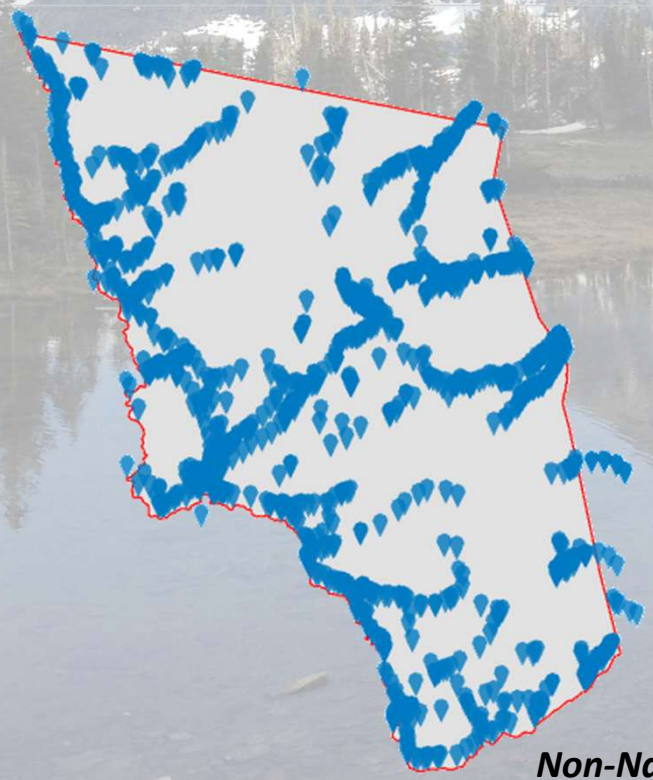
What potential factors contributed to the landcover changes in GNP?

Table of Invasive Plants → Display XY Data → **Points of Invasive Plants**

GNP U.S. Boundary → Clip to GNP boundary

Points of Invasive Plants + Clip to GNP boundary → **Invasive Plants within GNP** → Kernel Density

NLCD Change Index 2001-2016 + Kernel Density → Overlay → **Areas changed where invasive species are present**



	INFESTID.	LATINNAME	SPECIES	UTM_E	UTM_N	UTM_Zone	NAD
2	BR10-1-1	Chrysanthemum leucanthemum	CHRLEU	297033	5422268	12	83
3	BR10-1-10	Cirsium arvense	CIRARV	295537	5420719	12	83
4	BR10-1-11	Cirsium arvense	CIRARV	296087	5421485	12	83
5	BR10-1-12	Cirsium arvense	CIRARV	295614	5421060	12	83
6	BR10-1-13	Cirsium arvense	CIRARV	297209	5421888	12	83
7	BR10-1-14	Rumex crispus	RUMCRI	296400	5421600	12	83
8	BR10-1-15	Hieracium aurantiacum	HIEAUR	294408	5419843	12	83
9	BR10-1-2	Chrysanthemum leucanthemum	CHRLEU	297022	5422129	12	83
10	BR10-1-2	Cirsium arvense	CIRARV	297022	5422129	12	83
11	BR10-1-3	Cirsium arvense	CIRARV	296401	5421711	12	83
12	BR10-1-4	Cirsium arvense	CIRARV	294187	5419119	12	83
13	BR10-1-5	Cirsium arvense	CIRARV	298075	5422828	12	83
14	BR10-1-5	Cirsium vulgare	CIRVUL	298075	5422828	12	83
15	BR10-1-5	Silene vulgaris	SILVUL	298075	5422828	12	83
16	BR10-1-6	Cirsium arvense	CIRARV	296384	5421664	12	83
17	BR10-1-6	Ranunculus acris	RANACR	296384	5421664	12	83

Non-Native Invasive Plants within GNP

Expected Results and Anticipated Challenges

- Areas of the NLCD change index correlated to non-native invasive plants
- Percentage of land cover altered by non-native invasive plants*
- Land cover classifications that changed*
- Land cover classifications that resulted*

- Data is current for 2019 but does not distinguish when the data was collected
- Kernel density provides areas based on the point data but may not show true extent of non-native invasive plants
- May need to buffer each point to create an area in order to compare using raster calculator
- NLCD change index may not capture change due to resolution or no change in classification (shrubland may still be shrubland)

What potential factors contributed to the landcover changes in GNP?

GNP U.S. Boundary

Polygons of destructive insects

Clip to GNP boundary

Glaciers within GNP 2015

Polygon to Raster

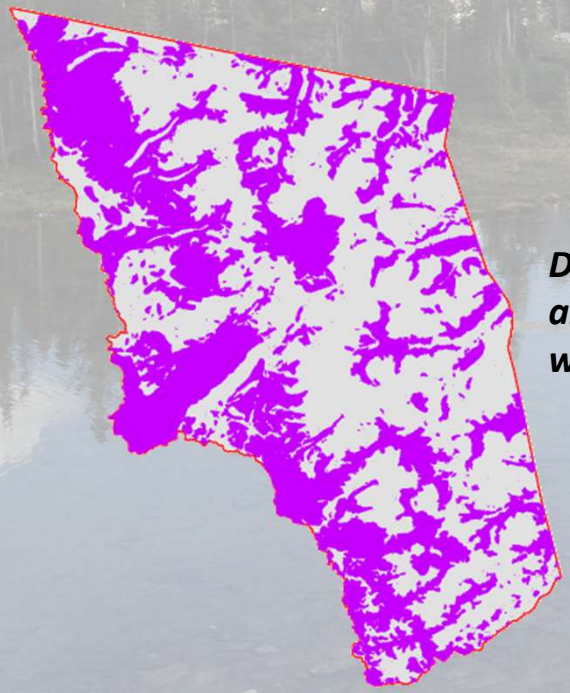
Reclassify Values: 0=No insects, 1-2=specific species (western spruce budworm & mountain pine beetle

NLCD Change Index 2001-2016

Reclassify Values: 0=No change, 1=Change

Raster Calculator: multiply values

Areas changed where destructive insects are present/caused damage

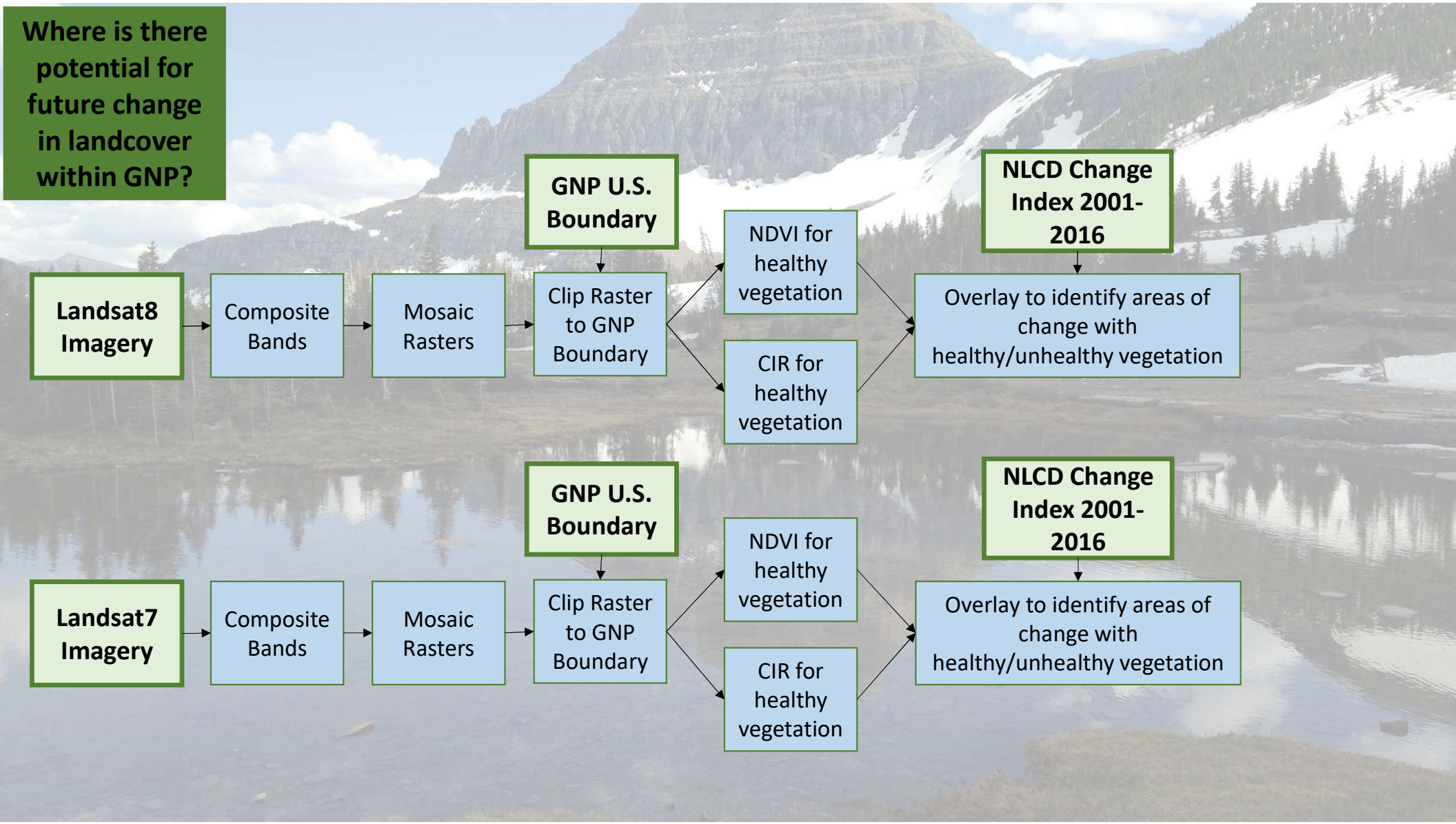


Damaged areas within GNP

Expected Results and Anticipated Challenges

- Areas of the NLCD change index correlated to destructive insects
- Area & Percentage of land cover altered by destructive insects
- Area & Percentage of damage caused by each species
- Land cover classifications that changed
- Land cover classifications that resulted
- Data to compare to areas affected by wildfire

- Only looking at two insect species: western spruce budworm & mountain pine beetle; others may exist
- May not show damage prior to/post wildfire
- Inaccurate or loss of data due to conversion from polygon to raster


Where is there potential for future change in landcover within GNP?
GNP U.S. Boundary
NLCD Change Index 2001-2016
Landsat8 Imagery
Composite Bands
Mosaic Rasters
Clip Raster to GNP Boundary
NDVI for healthy vegetation
CIR for healthy vegetation
Overlay to identify areas of change with healthy/unhealthy vegetation
GNP U.S. Boundary
NLCD Change Index 2001-2016
Landsat7 Imagery
Composite Bands
Mosaic Rasters
Clip Raster to GNP Boundary
NDVI for healthy vegetation
CIR for healthy vegetation
Overlay to identify areas of change with healthy/unhealthy vegetation

Expected Results and Anticipated Challenges

- Areas of healthy vs unhealthy vegetation
- Comparison of vegetation to change factors
- Land cover classifications that changed*
- Land cover classifications that resulted*

- Only looking at 2001 & 2016; study may need to expand to each NLCD year
- Vegetation health is not enough to show future change on its own
- May reflect potential for fire more than any other factor

Anticipated Results

- Correlated change factors to areas of land cover change in the NLCD change index
- Suggestions of other change factors that are not captured by one of explored options
  - Use of trail data, number of park visitors, vegetation classification, soil data, and elevation models
- Multiple maps isolating and comparing each factor
- Imagery analysis of vegetation

Questions?

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