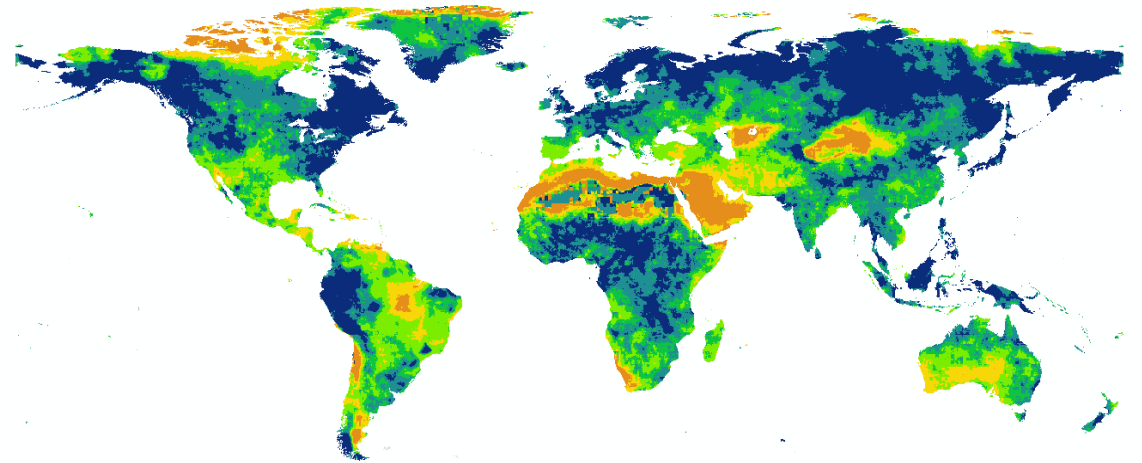# Resilient Analytics

PICHTR Resilience Webinar

Lead Technical Engineer: Jake Helman

Resilient Analytics, A Stanley Consultants Company

Climate Impacts are a Large Data Issue

Designing and Planning for the Future Requires Projections
The Alternative – Using Out of Date Historic Data

- For comparison: Historic climate data from 1950 – 2014 baseline

- Future Climate Projections
    - Climate data pulled for each location: daily precipitation, maximum daily temperature, minimum daily temperature, specific humidity, daily wind speed, etc.
    - US climate models are downscaled to a 1/16th degree of resolution (~3x3 miles)

- Over 3 Trillion Data Points in the United States.

Four Levels of Analysis

The Resilient Analytics' Climate Impact Analysis incorporates four levels of analysis to provide a path to answering key questions related to climate change impact.

The identification and quantification of climate-based risks to determine appropriate adaptation and resilience strategies from financial, social, environmental, and governance perspectives.

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Level 1: Awareness

- Key Question: What are the future climate conditions projected to be in specific geographic areas?

- Strategic Focus: Provide an awareness of projected threats to given locations including what are the projected threats and when are they projected to occur.
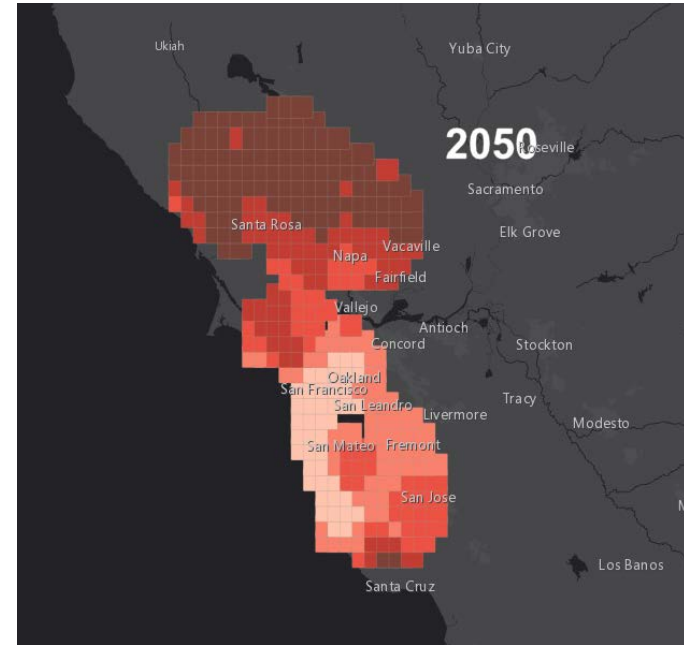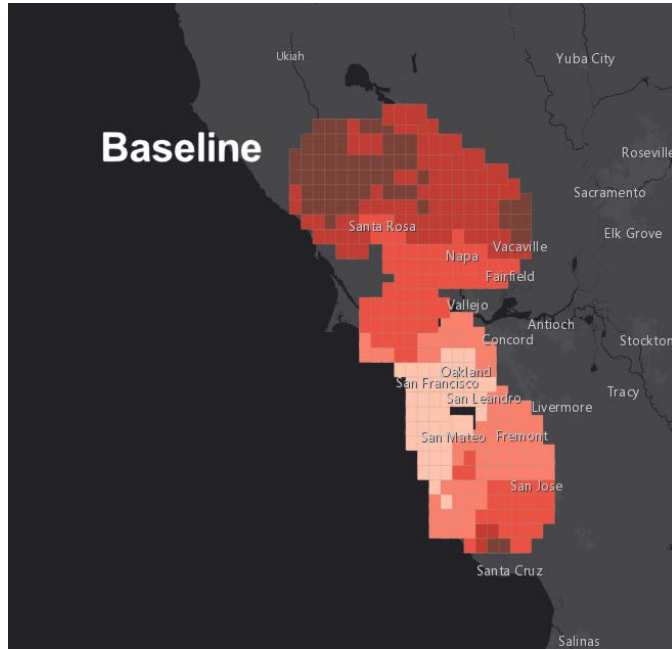
Level 2: Vulnerabilities

- A Vulnerability Analysis identifies the potential exposure of locations to climate change. A Level 2 analysis may address asset or system criticality whereby key assets having vulnerability may be identified early in the climate impact analysis process.

- Key Question: What specific assets, systems, and populations are vulnerable to projected climate change impacts?

- Strategic Focus: Provide an understanding of the vulnerabilities that assets, systems, and populations have to specific climate changes and when/where/how/why these impacts are likely to occur.

Asset Location

2050 Wildfire Danger

KBDI 2050

- > 650
- > 550-650
- > 450-550
- > 350-450
- >250 - 350
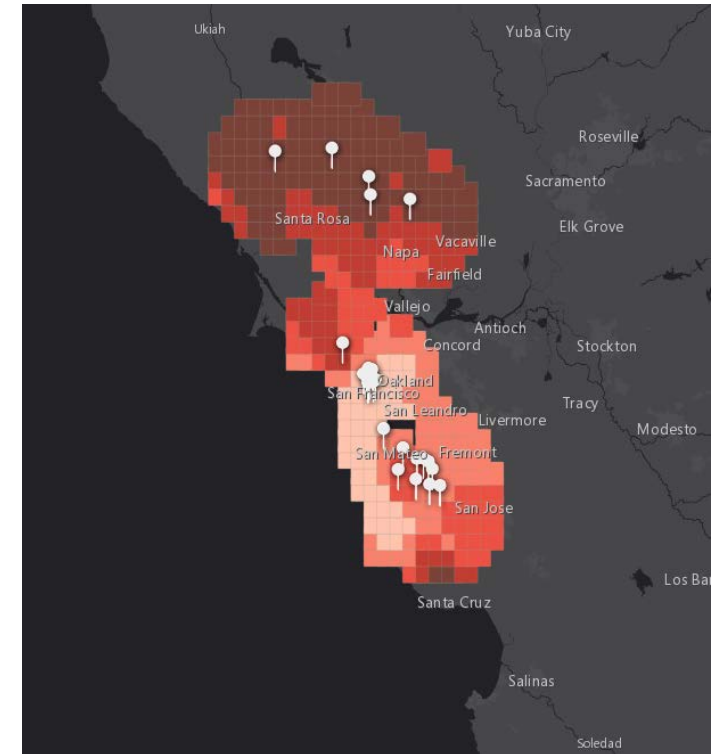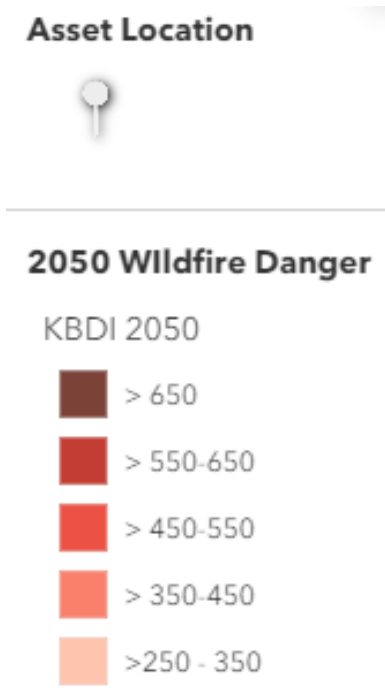
Level 3: Operational

- A Level 3 analysis is often considered a financial exposure or economic risk analysis as it identifies potential risks for investors through reporting tools such as TCFD.

- Key Question: What are the financial, social, and operational costs of climate change to assets/systems/populations in geographic areas of concern?

- Strategic Focus: Provide a quantitative perspective on climate change impacts including the cost/social/operational ramifications of individual impacts and the projected timeframe for impacts in the context of individual systems/assets/populations.

Level 4: Strategic

- A Level 4 analysis answers the key question of what can be done to mitigate or prevent the potential impact of climate change. In this study of options, multiple scenarios are examined to determine strategic approaches including investment, accommodation, and potential abandonment or sale of assets.

- The final result is an actionable strategic plan for addressing the physical and human risks associated with climate change.

- Key Question: What are the actions that should be taken in the near- and long-term to mitigate climate change impacts including appropriate adaptations and prioritization?

- Strategic Focus: Provide the starting point for a climate action plan including risk analysis, cost-benefit analysis, adaptation options, and social equity focal points within an overall prioritization strategy.
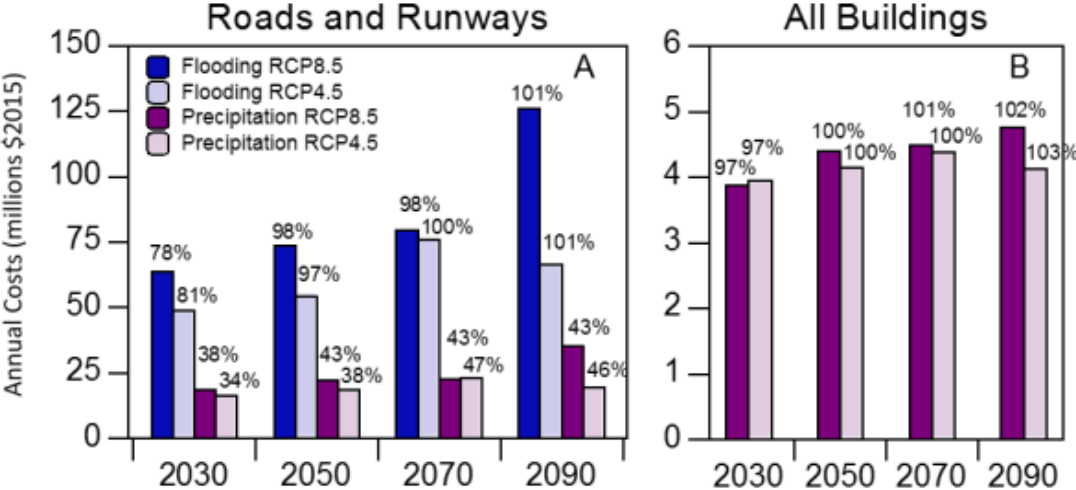
BOULDER, COLORADO
Cost impacts from 2020 to 2050

Wildfire area is projected to increase by 38%

Severity and length of droughts to increase

$4.6 million in cooling center operating costs

$16 million in investments to increase system capacity

Road maintenance to double to $1,130 per mile per year

$68 million for structural improvements to bridges

$19 million in adaptation costs for precipitation impact

Increase in cooling costs of 54% to 75%

BOULDER

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EPA NATIONAL CLIMATE IMPACTS STUDY

Risk factors for highways and bridges

No Adaptation

Reactive Adaptation

Proactive Adaptation

Change in Costs
(undiscounted, million $2018)

- -17 - 0
- >0 - 1
- >1 - 5
- >5 - 10
- >10 - 50
- >50 - 100
- >100 - 1,000
- >1,000 - 5,800

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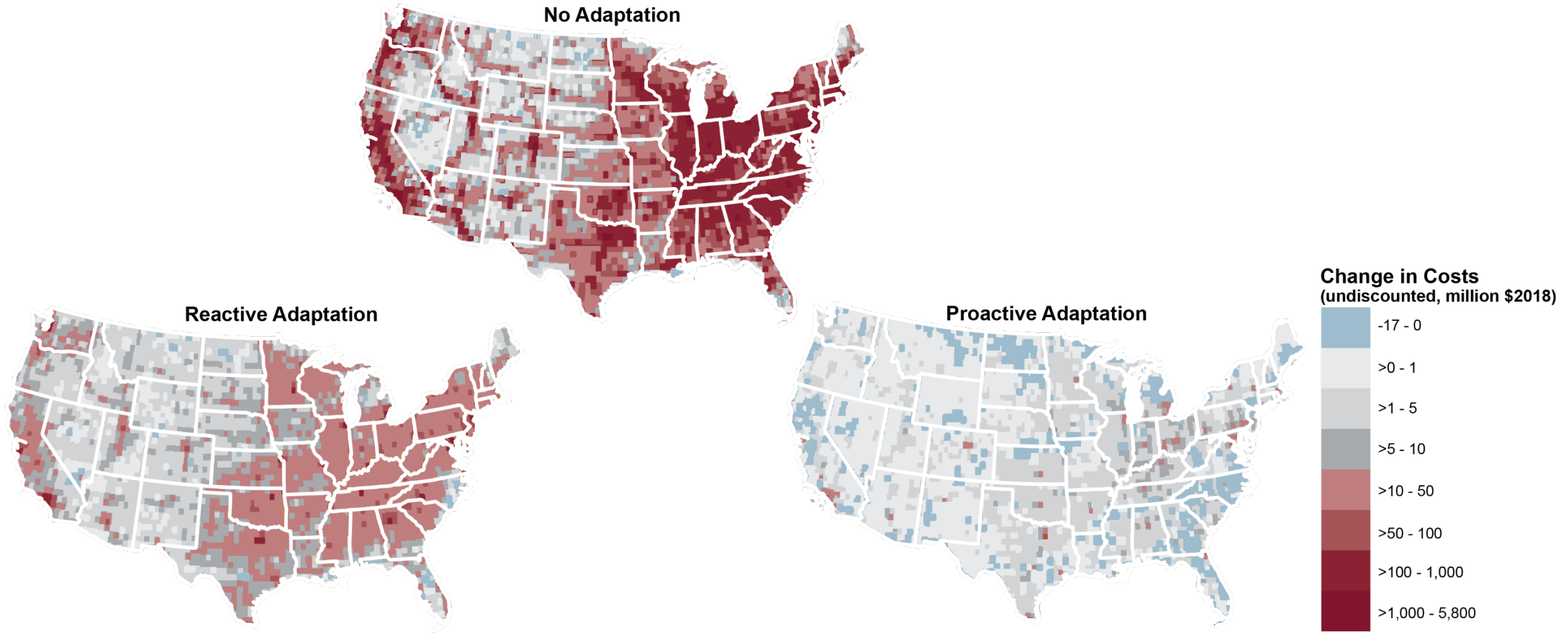
IMPACTS OF CLIMATE CHANGE ON OPERATION OF THE US RAIL NETWORK
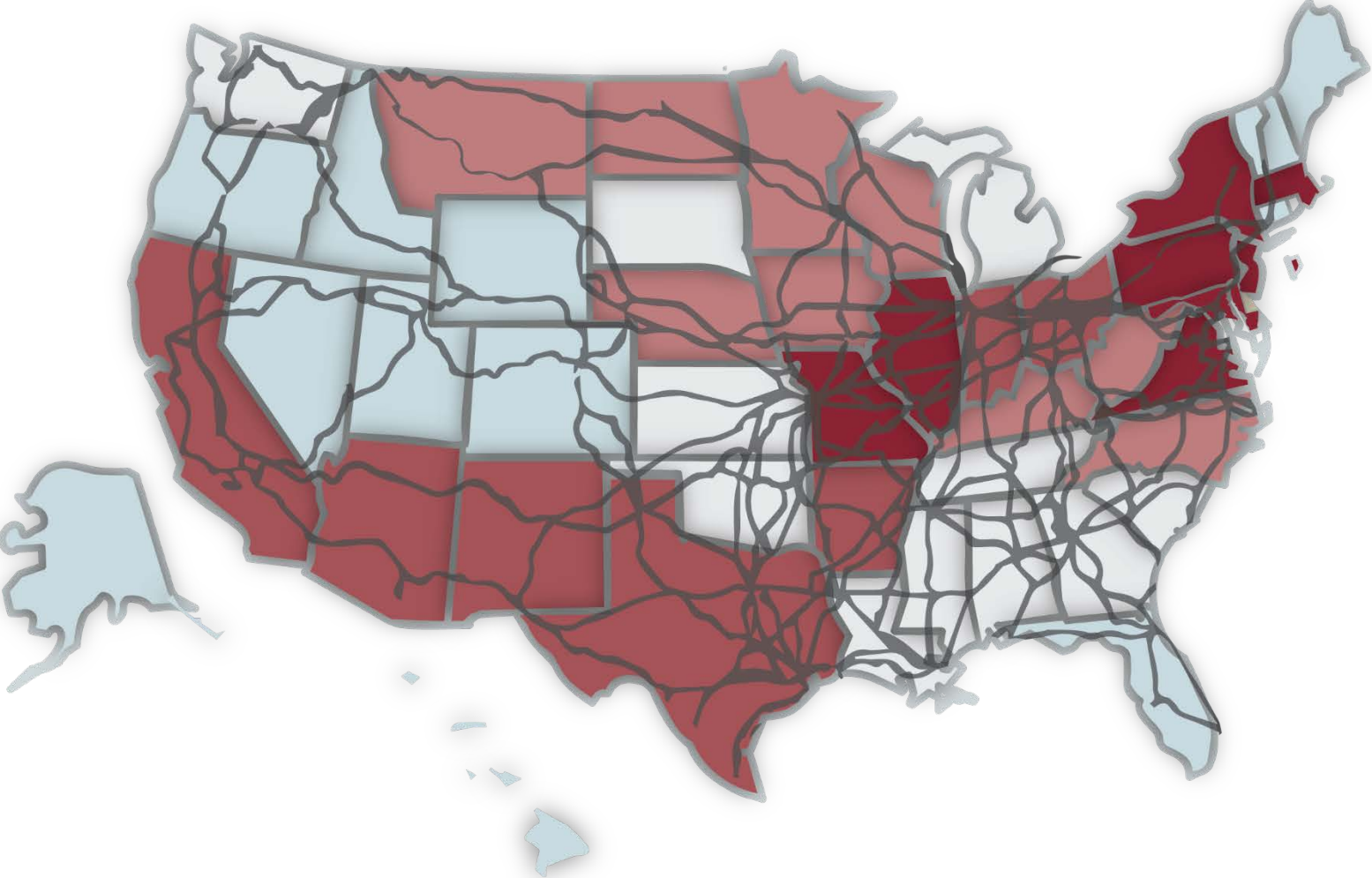
The primary freight and passenger rail network in the US comprises 140,000 miles of Class 1 rails operated by seven railroad companies

Each person in the US requires 40 tons of freight to be moved each year either through direct goods purchased or indirectly through bulk products such as coal which is required to generate electricity for individual users.

The Average Annual Costs For Rail Repair & Replacement
For Eras Containing 2050 and 2090

- $0 - $25,000
- $25,000 - $75,000
- $75,000 - $100,000
- $100,000 - $500,000
- $1,000,000 +

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NATIONAL SLR IMPACTS
State and city costs by 2040

Seattle/King County
$1257M

WA
$23.9B

Astoria
$330M

OR
$7.6B

San Francisco Bay Area
$3874M

CA
$22B

Los Angeles/Orange County
$1289M

San Diego County
$1289M

TX
$19.3B

Galveston
$1058M

New Orleans
$725M

LA
$38.4B

MS
$3.3B

Biloxi/Pascagoula
$1289M

Mobile
$718M

AL
$6B

GA
$15.1B

Savannah
$420M

FL
$75.9B

Tampa/St. Petersburg
$1689M

Jacksonville
$3461M

Charleston
$1032M

SC
$20.1B

NC
$34.8B

Nags Head
$424M

VA
$31.2B

Virginia Beach/Chesapeake
$2392M

Baltimore Area
$420M

MD

Atlantic City
$385M

NJ

PA
$0.05B

New York
$1974M

NY
$17.4B

RI

CT

NH

MA

Barnstable Town/Cape Cod
$889M

ME
$11B

MD	$27.4B
NJ	$25B
MA	$18.7B
DE	$9.4B
RI	$2.9B
NH	$1B

National costs due to sea level rise
Year 2040: $416B | Year 2100: $518B

State protection miles 15% increase in 60 years
Year 2040: 50,147 miles | Year 2100: 60,219 miles

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DATA CENTER RISK ANALYSIS

The data center risk analysis quantifies how climate change is projected to impact data centers across the US, with a specific focus on a facility in Santa Clara, CA. The analysis is broken up into three different categories: **design risk, operational risk, and acute risk**.

Design Risk: Represents the vulnerability of changes to building design standards, including HVAC.

Operational risk: Represents the vulnerability to changes in cooling energy and the amount of free cooling hours available at a location.

Acute risk: Represents the physical risks (flooding, wildfire, etc.) to the data center site and surrounding infrastructure.

■ Data Center Sites

□ No Sites
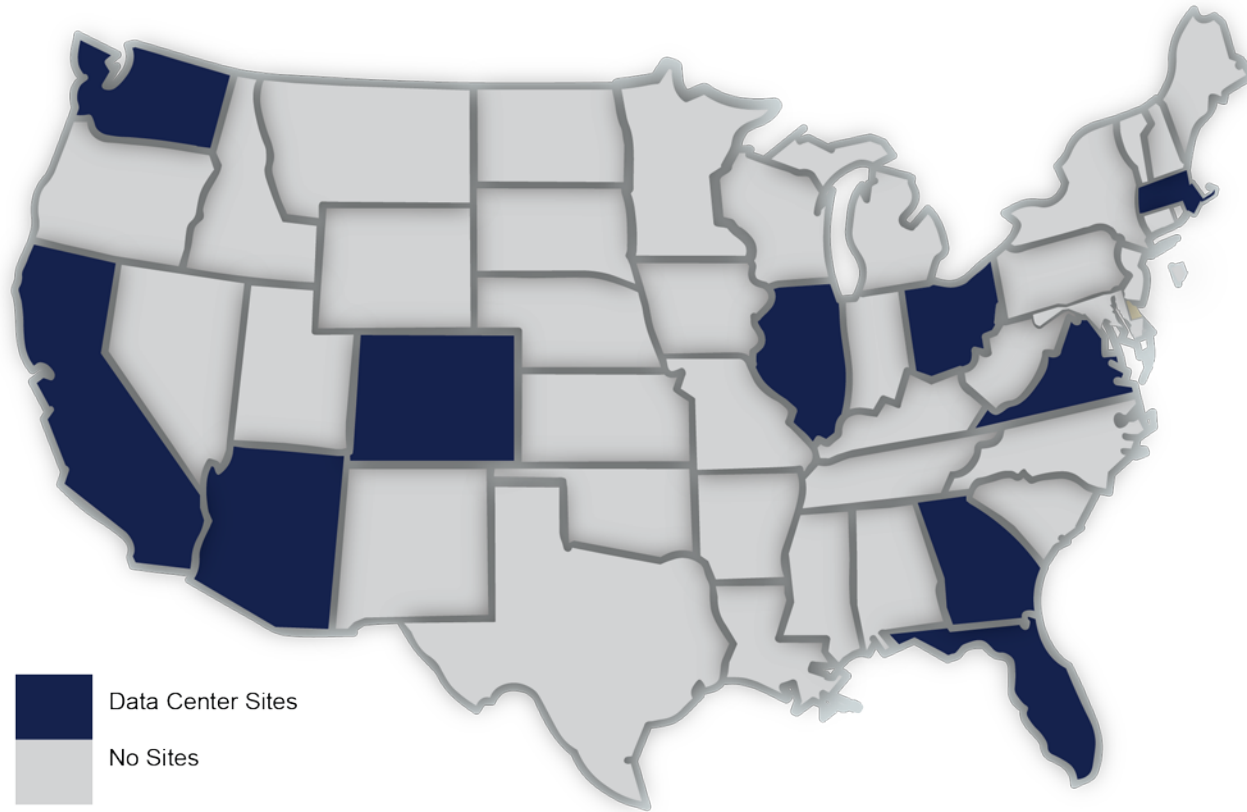
Key Findings For All 10 Sites:

Design Risks
- Extreme annual temperature is projected to increase for all locations by 0.9°F to 3.1°F by 2030 and 1.6°F to 5.1°F by 2050.
- 0.4% humidity ratio (grains of moisture/lb dry air) is projected to increase for all locations to 9.0% by 2050.

Operational Risks
- Cooling costs are projected to increase by 6% to 11% by 2030 and 13% to 24% by 2050.
- Total cooling costs are projected to increase by $3.5 to $6.6 million between 2020 to 2040.
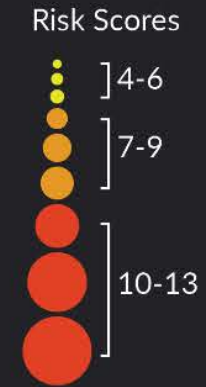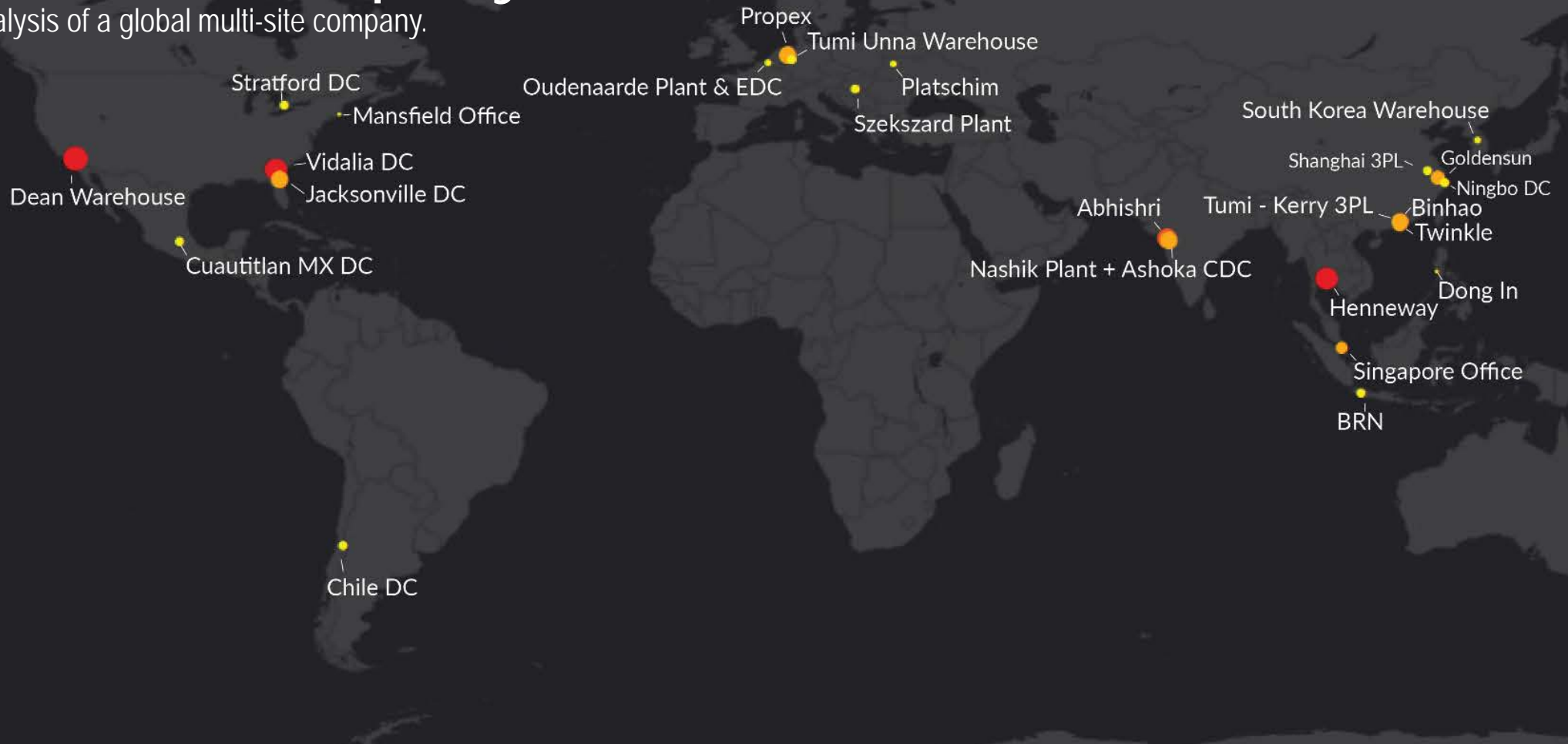
Acute Risks
- 70% of locations are projected experience an increase in extreme precipitation events by 2030.
- 30% of locations are projected to experience 20 additional days of extreme wildfire risk days annually by 2030.

Global Retail Company

- A risk score analysis of a global multi-site company.

Risk Scores

]4-6

]7-9

]10-13

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MULTI-SITE CLIMATE RISK STUDY

Risk factors for multiple real estate sites
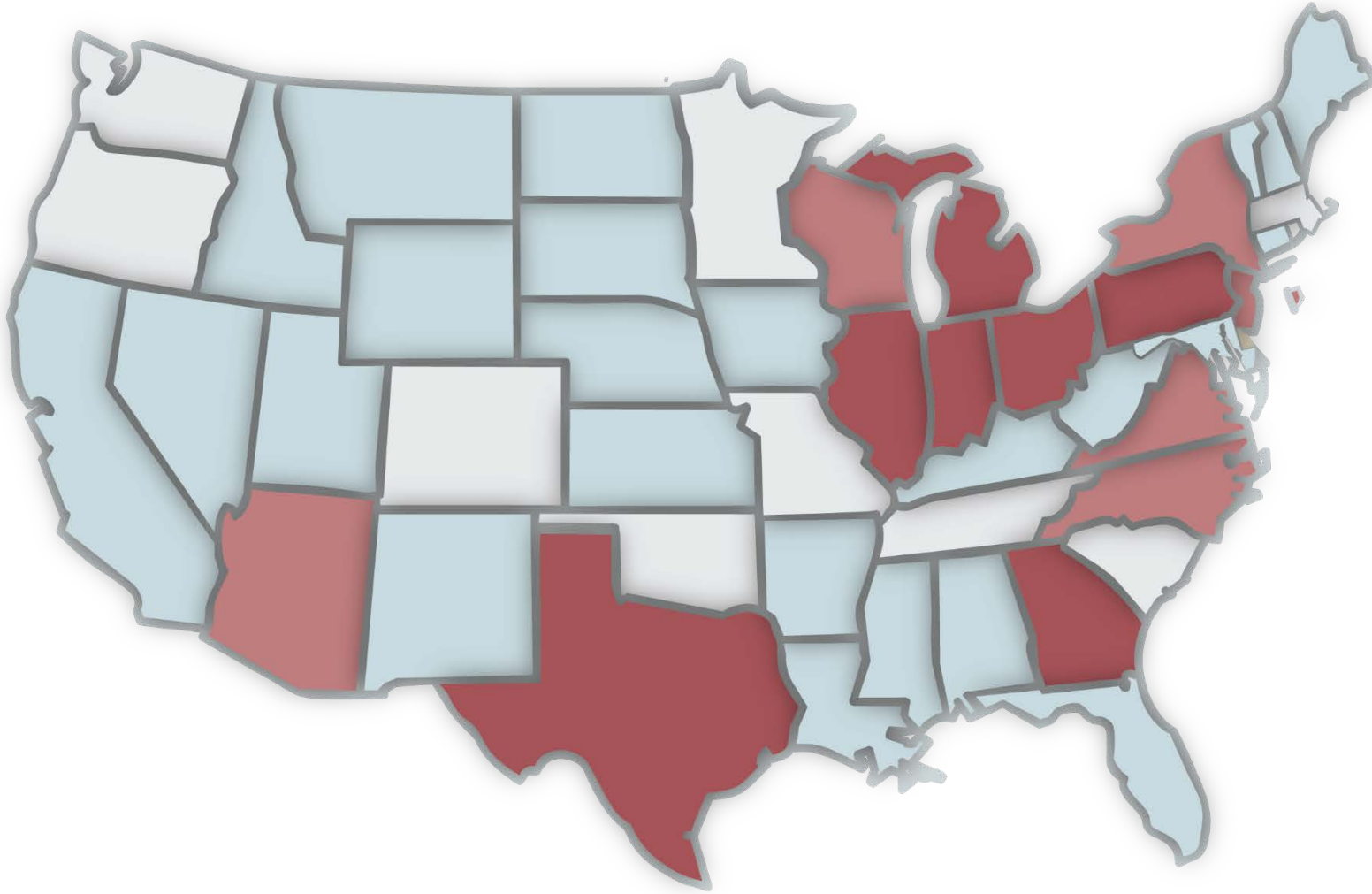
Number of Locations by Risk Factor

Risk Factor	Number of Locations	Percent of Locations
Temperature	50	19%
Flooding	26	10%
Drought	45	17%
Transportation	45	17%
Extreme Heat	38	15%
Allergens	10	4%
Sea Level Rise	5	2%
Precipitation	42	16%

Number of Sites at Risk in Each State from Climate Factors

	10+ sites	7 States
	7-9 sites	7 States
	4-6 sites	8 States
	1-3 sites	15 States

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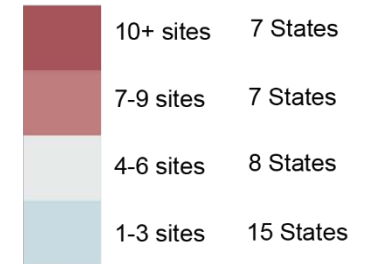
NATIONAL SCHOOL HEAT STUDY

Percent of schools in a given state that are too hot
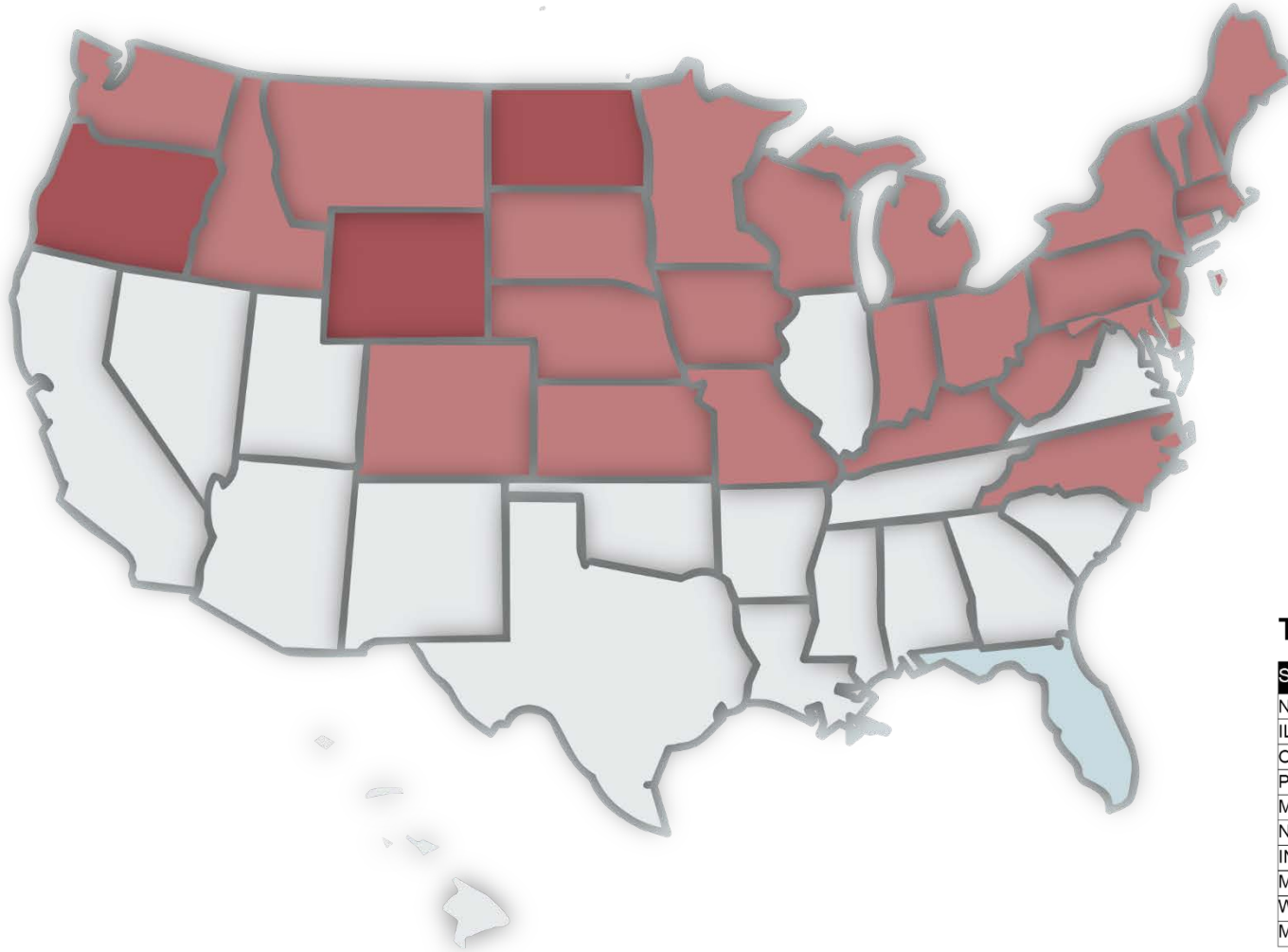
Top 10 States By Costs (in millions)

State	New AC	Upgrade AC	Annual Cost	Total Cost
NY	$9,384	-	$248	$9,633
IL	$7,875	$14	$166	$8,056
OH	$7,747	$8	$163	$7,919
PA	$6,561	$4	$129	$6,696
MI	$6,347	$0.4	$146	$6,494
NJ	$5,652	$0.3	$144	$5,796
IN	$4,459	$7	$109	$4,576
MN	$3,519	-	$63	$3,583
WI	$2,535	-	$47	$2,583
MA	$2,437	-	$35	$2,473

50-59.99% 3 States

40-49.99% 24 States

30-39.99% 17 States

20-29.99% 2 States

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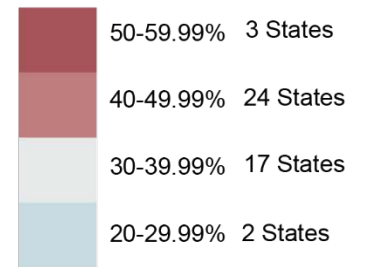
IMPACTS OF CLIMATE CHANGE ON ALASKAN INFRASTRUCTURE

Most significant damages located in interior and South Central Boroughs due to permafrost thaw.

Extremely mild to no damages in Southwest Boroughs

Permafrost Thaw:
As Earth's climate warms, the permafrost is thawing. That means the ice inside the permafrost melts, leaving behind water and soil. When permafrost is frozen, plant material in the soil—called organic carbon—can't decompose, or rot away. As permafrost thaws, microbes begin decomposing this material.

Climate Change Damage Costs in Millions of Dollars (2015–2099) 3% discount, RCP 4.5

< $0

$10 - $100

$100 - $300

> $300

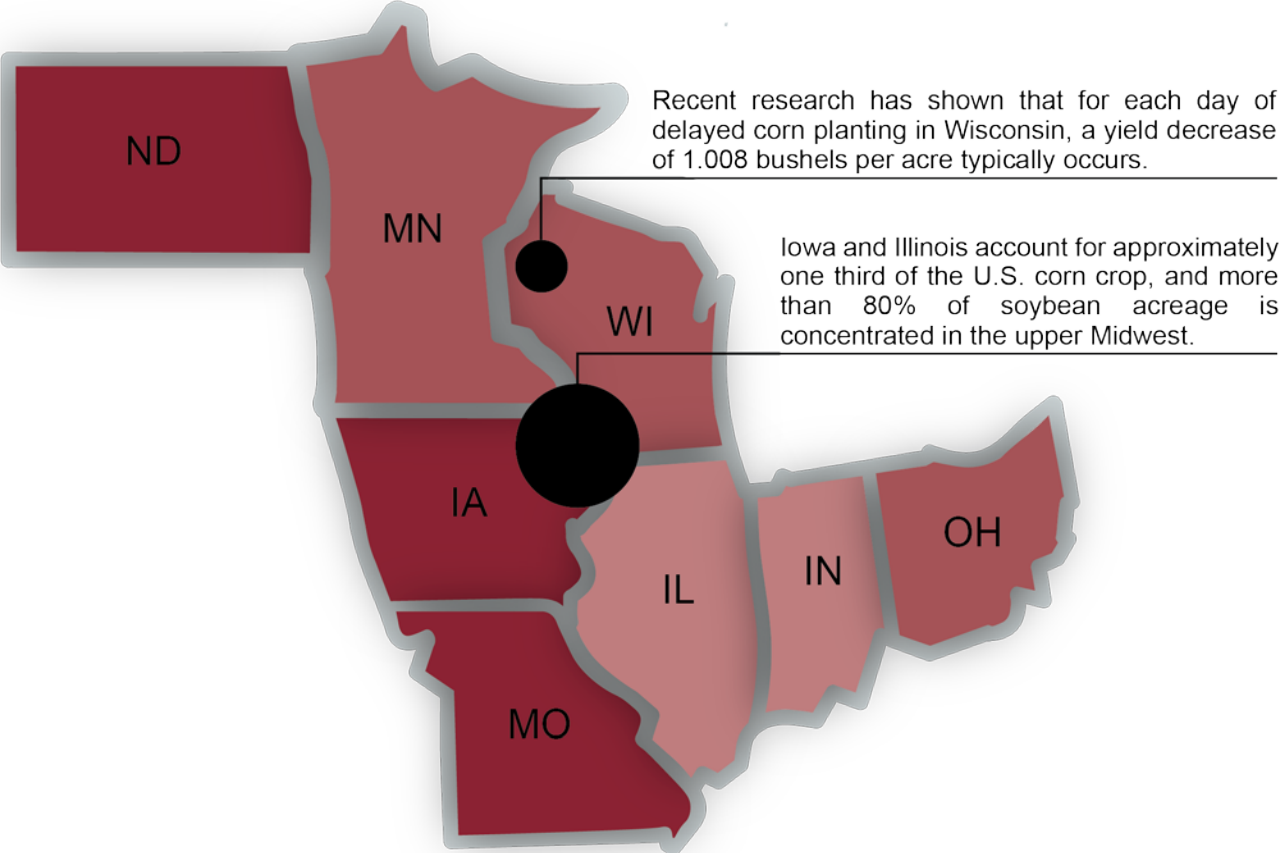Negative costs reflect benefits

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IMPACTS OF CLIMATE CHANGE ON THE AGRICULTURE SECTOR

ND

MN

WI

IA

OH

IN

IL

MO

Recent research has shown that for each day of delayed corn planting in Wisconsin, a yield decrease of 1.008 bushels per acre typically occurs.

Iowa and Illinois account for approximately one third of the U.S. corn crop, and more than 80% of soybean acreage is concentrated in the upper Midwest.

For corn, each degree of warming during June–Aug is capable of suppressing yields by as much as a 19% decrease compared to current. **It is a very sensitive crop to rising temperatures**

Winter warming may lead to **overwintering of pests**. Increase in **more frequent heavy rainfall** is the new normal, and farmers need to be prepared.
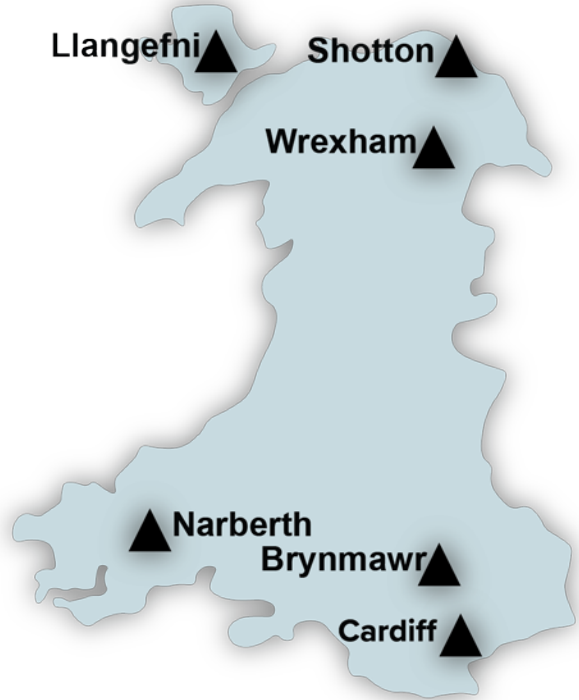
Yields from **major U.S. commodity crops are expected to decline** as a consequence of higher temperatures, especially when these higher temperatures **occur during critical periods of reproductive development.**

Growing Degree Days (GDD):
Used to **estimate the growth** and development of plants and insects during the growing season. The basic concept is that **development will only occur if the temperature exceeds some minimum development threshold, or base temperature.**

Climate Change During Growing Season (May-Sept.)
RCP 4.5 2050 vs. Historic Data

Location	Precip. % Change	GDD % Change
MO	-8%	14%
IN	3%	14%
IL	0%	18%
OH	-1%	19%
IA	-8%	17%
WI	-1%	24%
MN	-4%	20%
ND	-10%	20%

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IMPACTS OF CLIMATE CHANGE ON THE HOUSING STOCK OF WALES

Llangefni ▲

Shotton ▲

Wrexham ▲

▲ Narberth

Brynmawr ▲

Cardiff ▲

Climate Impacts to Housing

• Changes in outdoor temperature and humidity can drive changes in indoor conditions

• Rising indoor temperatures can lead to overheating risk and decreased thermal comfort

• Increased indoor relative humidity can result in diminished indoor air quality from contaminants like mold and fungus

Percent of Hours Above 26°C for 11 Building Classes
Average Across 6 Locations
July 22nd - August 31st

Legend:
- Baseline
- 2030
- 2070
- – – – 3% of Occupied Hours - Thermal Comfort Threshold

Y-axis: Percent of Hours (0% – 30%)

Categories: Average Dwelling, Pre - 1919, 1919 - 1990, Post - 1990, Timber Frame, Solid Stone, Solid Brick/Cavity, Attached, Detached, Flat, Internal Wall Insulation, Double Glazing Pre - 1919
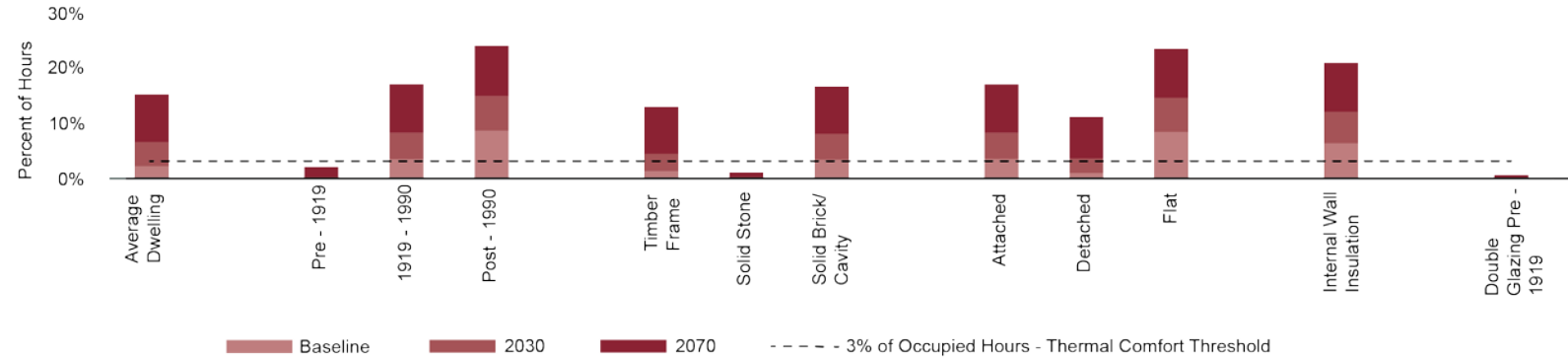
Daily Maximum Relative Humidity for 11 Building Classes
Average Across 6 Locations
July 22nd - August 31st

Legend:
- Baseline
- 2030
- 2070
- – – – 60% Relative Humidity - Indoor Air Quality Threshold

Y-axis: Relative Humidity (0% – 80%)

Categories: Average Dwelling, Pre - 1919, 1919 - 1990, Post - 1990, Timber Frame, Solid Stone, Solid Brick/Cavity, Attached, Detached, Flat, Internal Wall Insulation, Double Glazing Pre - 1919

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