



Climate Change Hazards Summary Report for Facility Investment Planning

Indiana Dunes National Park January 2021

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Introduction

Parks are required to complete a PARK Project Narrative Template for each proposed Great American Outdoors Act Facility Investment Plan (GFIP) project for Legacy Restoration Funding in fiscal years 2023-2025. Information provided in this report is intended to help parks consider climate change-related hazards when addressing Question 16 of the narrative template.

Specifically: What risks or hazards (current and projected, e.g. effects of climate change) are likely to affect this project? If applicable, what adaptation strategies and/or resiliency measures have been identified for scenarios that pose high risks to project assets?

Step 1: Review summary information for known or potential hazards identified for Indiana Dunes National Park

- Review the list of potential hazards below and decide whether or not they apply to your specific GFIP project. NPS Climate Change Response Program (CCRP) staff attempted to identify potential hazards for the park; however, park staff and project planners have more information about hazards that are likely to be applicable to a specific project.
- The hazards below were selected from a longer list included in Appendix 1, which also indicates CCRP's 'best professional judgement' about the relevance of the hazard for this park. Note both lists serve as a 'coarse filter' screening tool to help identify potential climate-related hazards for facility and asset planning.

Hotter average days and more very hot days

Climate change is already driving observable increases in average and extreme temperatures, and this trend is projected to continue, with record-setting years becoming more common in the future (USGCRP 2017). The annual average temperature in the United States is expected to increase by 2.3 to 11°F by the end of the century depending on greenhouse gas emissions, relative to 1986-2015 (USGCRP 2018). Extreme temperatures can increase weathering of structures, threaten park staff and visitor safety, and increase stresses for HVAC systems. Demand for complex air conditioning systems can add stress to building envelopes and often requires significant alterations to a structure.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
☐ No

Increased drought frequency, intensity, magnitude, and duration

Rising air temperatures and changing precipitation patterns are exacerbating drought risk in many parts of the United States (Wehner et al. 2017). Changing drought conditions (frequency, severity, duration) can challenge a variety of infrastructure and operations (Department of Homeland Security 2015) in the NPS (e.g., water supply and wastewater systems), impair water quality (Mosley 2015), affect soil heaves

and shrinkages (Fernandes et al. 2015), and enhance other related risks such as wildfire (Halofsky et al. 2020).

The Midwest U.S. experiences intermittent, damaging droughts, despite increasing precipitation. Future drought behavior is uncertain in this region, but climate change projections show that Midwest surface soil moisture will transition from saturated in the spring (due to increasing precipitation) to rapid drying in the summer, driven by higher temperatures (Wehner et al. 2017, Angel et al. 2018). The 2012 drought was the most intense and widespread drought on record for the past hundred years (Jin et al. 2019) and developed quickly with rapid intensification as summer temperatures increased. These "flash droughts" are expected to increase in frequency and severity due to increasing precipitation variability and rising temperatures and will challenge water resource management throughout the region (Pendergrass et al. 2020). Rapidly changing soil moisture with soil shrinkage and heaves can cause soil cracking and structural issues with pipes, roads, and buildings (Fernandes et al. 2015).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Increased wildfire frequency, intensity, magnitude, and duration

Wildfire is a natural part of many forest, woodland, and grassland ecosystems. Excessive fire, however, can damage ecosystems, kill people, and damage infrastructure. Climate change is intensifying the heat that drives wildfire (Jolly et al. 2015) and altering the distribution and density of vegetation that comprises the fuel for wildfires (Gonzalez et al. 2010). These effects combine with the unnatural buildup of coarse woody debris and understory trees from decades of suppression of all fires, even natural ones (Agee and Skinner 2005). The effects of climate change on wildfire vary across landscapes. For areas where projected climate change increases fire risk, buildings, cultural landscapes, or other infrastructure located under or near tree canopies or dense grasslands are vulnerable to burning and destruction.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Altered precipitation patterns and changing humidity

Changing precipitation patterns have been observed in many regions of the United States as result of climate change and changes are expected to continue. Depending on the region in the United States, increases or decreases in precipitation have been experienced (USGCRP 2018). Changing precipitation and humidity conditions can result in local flooding, encourage mold growth, wood decay, increase fire risk, and intensify drought conditions, depending on the pattern of change.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes

☐ No

Increased extreme precipitation

Increased frequency and intensity of extreme precipitation events has been attributed to climate change within some regions of the United States and such increases are projected to continue over the next century (USGCRP 2018). Furthermore, the intensity of extreme precipitation events increase with increasing temperatures (Easterling et al. 2017). Extreme precipitation events present a variety of threats to infrastructure and operations, including flooding of sites (possibly leading to sustained loss of power, water, sewer and access infrastructure), sewage backup, accelerated decay of masonry, overcoming drainage systems, road wash out, cracks in building infrastructure, destabilization of roads, pilings, buildings and pipes, erosion of supporting ground around structures. Increased humidity, flooding, and driving rain can damage building cladding, increase risk of mold and rot, and promote insect damage, among many other effects.

The frequency of intense precipitation throughout the MWR increased up to 53% from 1958-2016, especially in the upper central and Great Lakes states (Easterling et al. 2017) and projections for all emissions scenarios are for additional increases in the future.

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Sea/lake level change and coastal storm surge

Current methods for projecting future water levels, and their variability, have very little skill for Lake Superior (Olivia LaDee, Midwest Climate and Adaptation Science Center, pers. comm. to Gregor Schuurman, Sept 2020). At the moment, the current levels of variability are the best available information (ibid).

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Riverine flood/Flash Flood

Extreme precipitation events and the risk of flooding are expected to regionally intensify with a changing climate (Dethier et al. 2020, Tabari 2020). Floods threaten infrastructure and operations through a variety of mechanisms, including inundation of structures, enhanced erosional forces, road wash out, structural collapse from force of floodwaters, sewage backup, and damage to utilities, generators, and electrical systems. Post-flooding effects include increased rot, fungal/insect attack, mold and mildew, and physical deterioration of wood, brick and stone building materials.

Increased annual precipitation (Melillo et al. 2014), and increased frequency and intensity of heavy rain events (Easterling et al. 2017), have increased the overall flood risk in the Midwest region. Dethier et al. (2020) found annual high-flow frequency has increased in the midwestern U.S. comparing the past two

decades (2007-2016) to the reference period 1950-1969. While flood frequency appears to be increasing in the Midwest, the largest flood peaks have not been strongly increasing across the region (Mallakpour and Villarini 2015). Winter and spring precipitation, which play an important role in flood risk for the region are projected to increase by 30% by the end of this century (Angel et al. 2018). Within region flood trends show high spatial variability depending on catchment conditions and the flood generating mechanism. In many cases climate is just one factor leading to flooding (Peterson et al. 2013), with urbanization and other land cover changes exerting a strong influence (Criss and Luo 2017, Angel et al. 2018). In some cases it is inadequate to assume that design flood values will remain stationary in the future as climate changes (Van Dusen et al. 2020). As a result, local studies to characterize changes in extreme flows (Van Dusen et al. 2020) or increases in current safety factors may be necessary to account for climate change in infrastructure design.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Hurricanes and tornadoes

Hurricanes are projected to increase in intensity and precipitation rate in a warmer world (USGCRP 2017). Hurricanes threaten structures via damage from wind, wind-blown rain and debris; their large temperature swings stress buildings through sudden thermal expansion and can crack pipes; they also can cause flooding and road wash outs. With continued climate change, the potential for severe thunderstorms that provide conditions for tornadoes may increase substantially (Abell et al. 2007, Diffenbaugh et al. 2013, Gensini and Mote 2015). Tornadoes can result in catastrophic damage to infrastructure from high winds, and associated debris, hail, and flash flooding.

In the midwestern U.S., under the highest emissions scenario, models project more than a 40% increase from 2000 to 2100 of the number of days in spring with severe thunderstorms that could produce tornadoes (Diffenbaugh et al. 2013).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Pest infestation

Increased temperatures and CO₂, changes in precipitation, and disturbance due to extreme climate events can increase the survival, spread, growth, and establishment of pests (IPCC 2014). Rooting and burrowing mammals and termites have the potential to cause direct damage to power, water, transportation, and building facilities (Vissicelli 2018). Facilities may be impacted indirectly through other mechanisms exacerbated by climate change such as forest insect pest invasions or fluctuating ground water levels leading to increased tree mortality, hazard trees, and treefall.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Invasive species

Increased temperatures and CO₂, changes in precipitation, and disturbance due to extreme climate events can increase the survival, spread, growth, and establishment of invasive species (IPCC 2014). Weeds and aquatic mussels have the potential to cause direct damage to power, water, transportation, and building facilities (Vissichelli 2018). Non-native species that may not currently impact facilities may become harmful due to changes in local climates (NRC 2002, IPCC 2014).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

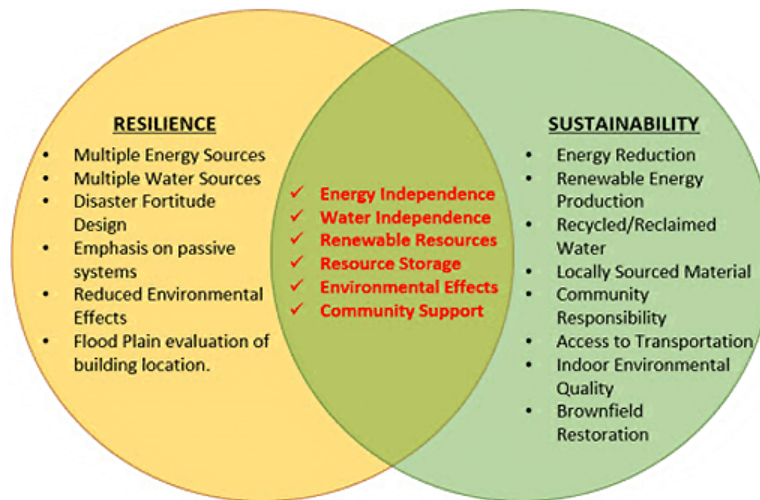
Step 2: Consider adaptation and resiliency strategies

- Review definitions of resiliency and adaptation strategies.
- Identify adaptation strategies that will help park resources respond to the hazards identified in Step 1.

Question 16 requires a screening for climate hazards followed by a review of adaptation and resiliency strategies that would be put in place to respond to these hazards. For the purposes of this report and investment planning, resilience is a property of a system or asset and generally refers to the ability of the system or asset to maintain its intended purpose following a temporary disturbance.

Adaptation strategies, in the context of built infrastructure, refers to the intentional management decision to identify, prepare for, and respond to observed or expected sustained changes in hazards, including climate change, to adjust to a sustained change in conditions.

It is important to note that resilient park operations can be supported through the use of green infrastructure such as sustainable landscaping, as well as sustainable energy, water, and building envelope solutions. The figure below illustrates this relationship.



Lists of adaptation strategies for different types of infrastructure projects in response to different hazards can be found here: [Incorporating Climate Change Adaptation in Infrastructure Planning and Design](#) (see Chapter 4, Tables 25-34). If used, these adaptation strategies will need to be modified for proposed park projects.

Buildings and assets within national parks may include cultural resources (e.g., historic and pre-historic buildings and structures). Adaptation strategies for cultural resources often overlap with those defined for facilities; however, the NPS has detailed strategies for dealing with cultural resources and climate change in national parks ([Cultural Resources Climate Change Strategy](#)). “Climate change poses an especially acute problem for managing cultural resources because they are unique and irreplaceable — once lost, they are lost forever.” ([NPS Policy Memorandum 14-02](#)).

Step 3: Develop an answer to Question 16 for your specific project and location, as well as strategies to address each hazard

- Two example responses to Question 16 are provided below. THESE ARE GENERIC EXAMPLES FROM OTHER PARKS.
- You will need to modify the answers below based on the hazards identified in Step 1 and the adaptation strategies identified in Step 2 for your park and project. The park response should be as project-specific as possible.

Question 16: What risks or hazards (current and projected, e.g. effects of climate change) are likely to affect this project? If applicable, what adaptation strategies and/or resiliency measures have been identified for scenarios that pose high risks to project assets?

Example from Minute Man National Historic Park: Restoring historic structures

Several climate change hazards may affect building-related projects at MIMA, including hotter average days, more extreme heat days, increased hurricane impacts from wind and flooding, altered precipitation patterns, and increased extreme precipitation. Adaptation and resiliency strategies for the expected hazards are described below:

- Hotter average days and more extreme heat days will increase demand and requirements for higher-capacity air conditioning systems.
- Extreme heat and humidity can stress the building envelope and will require significant humidity control alterations for structures.
- Hurricane-force wind and wind-blown rain as well as damage from wind-blown debris or treefall will require wind-resistant fortification of the structure. Addressing hazardous trees and retrofitting roof structures to be more wind resistant may also be required.
- Flooding from increased extreme precipitation may require modifications to building infrastructure location and landscape drainage systems.
- Post-flooding effects may include increased rot, mold and mildew, and physical deterioration of wood, brick and stone building materials. Adaptation actions will include identifying appropriate dehumidification and air handling systems and coordinating with the NPS Historic Architecture, Conservation and Engineering Center or Historic Preservation Training Center regarding alternatives and maintenance for historic structures.

Example from Grand Teton National Park: Building assets, water development, or road construction

Several climate change hazards may affect projects in GRTE, including hotter average days, more extreme heat days, increased drought frequency and intensity, altered precipitation and flooding patterns, increased wildfire, and increased invasive species abundance or distribution. Some example adaptation and resiliency strategies for the expected hazards are described below:

- Hotter average days and more extreme heat days will increase demand and requirements for higher-capacity air conditioning systems.
- Energy demand increases should be offset by conservation measures and renewable energy implementation where possible.
- Extreme heat can stress the building envelope and may require significant humidity control alterations for structures.
- Increased and more intense wildfires will require more planning in the wildland-urban interface, either by relocating park assets, using fire-resistant building materials, reducing fuels near structures, or all of these measures.
- Increased drought and faster runoff can reduce the amount of water available for park use. New water sources might need to be identified and water conservation measures should be prioritized.
- Heavy rains during the spring thaw can cause rapid melting of the snowpack, resulting in severe flooding. Road construction may require relocation, as well as larger culverts and other flood control measures to accommodate heavy runoff.
- Buildings, infrastructure, and roads in existing flood zones may need additional mitigation.

- The potential for increased invasive species should be mitigated. Measures include mitigation during construction (e.g., using weed-free gravel and cleaning construction equipment) and increased weed treatment post construction.
- Termites are likely to arrive in GRTE by mid-century. Early detection monitoring and eradication, if possible, will help protect historic structures and other buildings.

Step 4: Seek additional assistance if desired

- Additional resources for answering question 16 and related questions can be found in:
 - Appendix 1 below, which includes a full hazards checklist, providing additional links for supporting information related to each hazard.
 - Appendix 2 below, which provides a map to visualize how climate is changing for the park.
 - The [GFIP Guidance and Logistics](#) folder under the [Resources to Assess Risks and Hazards tab](#) includes:
 - An Excel workbook labeled [T75 Parks GFIP NRSS Supporting Materials](#) that provides links to information for natural resources to be considered during project design and construction.
 - A [FAQs – Assessing Risks and Hazards](#) document that provides detailed guidance for answering Question 16.
 - A [Natural Hazard Assessment Webinar](#) recording that provides key information, definitions, and guidance for understanding natural hazards and related resources.
- The NPS Climate Change Response Program (CCRP) and Sustainable Operations and Maintenance Branch (SOMB) are also available for assistance in evaluation of climate change hazards and resiliency strategies as they relate to specific projects. Questions can be sent to the NPS [GFIP Hazards and Risk Assistance email account](#) and a member of that team will reply with support.

Appendix 1: The Climate-Related Hazard Checklist

This appendix provides an initial evaluation of climate hazards for **Indiana Dunes National Park** according to the hazard ratings identified below. The information used to identify hazards in the checklist is mostly from regional assessments. Park- and project-specific information was generally not available when assessing these hazards. NPS Climate Change Response Program (CCRP) staff made an initial attempt to identify potential hazards for the park broadly (see 'Best Professional Judgement' column); however, park staff and project planners have more information about hazards that are likely to be applicable to a specific project.

Explanation of Hazard Ratings

Known hazard: Conditions that cause the hazard are well documented in the area where the park occurs. If applicable to the project site, these hazards should always be addressed in the project plan.

Potential hazard: Conditions that cause or underlie the hazard are known to occur nearby or are likely to occur based on studies with conditions similar to the park. If applicable to the project site, these hazards should be addressed in the project plan.

Not applicable: No evidence *was identified* showing this hazard is relevant to the park. Note this is a coarse filter evaluation; local knowledge of a hazard(s) should be used, when available.

Table 1. Climate-related Hazards Checklist

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Hotter average days and more very hot days	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Inadequate HVAC • Road surface degradation • Lack of water due to increased water for irrigation • Increased humidity • Danger to staff	• National Climate Assessment	• National Climatic Data Center • DAYMet gridded climate data • National park historical and projected climate change

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Increased drought frequency, intensity, magnitude, and duration	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Limited water supply for cooling, landscaping, structural fire suppression, other equipment • Increased competition for available water and water rights conflicts • Crack/heave damage in drier soils • Increased vulnerability to wildfire (below)	• Drought Monitor • National Integrated Drought Information Center • National Climate Assessment	• Drought Monitor • National Integrated Drought Information Center
Increased wildfire frequency, intensity, magnitude, and duration	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Damage to facilities and contents • Smoke damage • Air quality dangerous to staff and visitors • Increased runoff • Increased erosion • Damage to water treatment plants	• Barbero et al. 2015 International Journal of Wildland Fire	• NIFC • International Wildland-Urban Interface Code
Altered precipitation patterns and changing humidity	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Local flooding • Mold growth • Wood decay • Drought • Fire • Groundwater change	• National Climate Assessment	• National Climatic Data Center • DAYMet gridded climate data • National Park historical and projected climate change

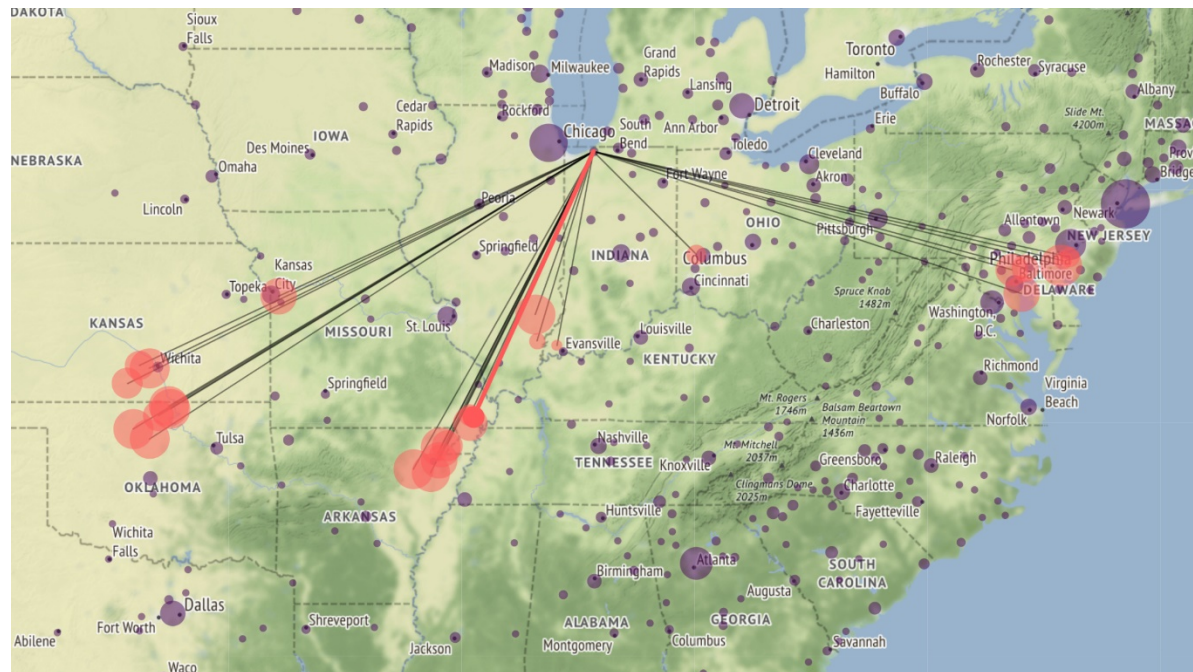
Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Increased extreme precipitation	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Surface erosion • Floods (see below) • Water damage to structures from driven rain • Unstable saturated soils	• National Climate Assessment	• Evaluations are mostly at regional scales
Riverine flood/flash flood	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Damage or destruction of infrastructure • Stream channel migration • Stream bank erosion/extreme erosion • Safety • Water quality diminished • Damage to water source and delivery infrastructure • Changing requirements for culvert flow capacity	• FEMA Flood map service	• FEMA Map Service Center • Floodplain maps for HUD projects • Van Dusen et al. 2020 (for select parks) • May require a special flood study
Sea/lake level change and coastal storm surge	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Rising lake levels • Rising water – wind driven (e.g. hurricane, nor'easter) • Vegetation damage	• NOAA SLR viewer • NOAA - Great Lakes Environmental Research Laboratory	• IRMA – Coastal reports • NPS SLR viewer • Specific Hazard Assessment: Coastal Storm Surge with Climate Change Effects(requires VPN connection) • SLR reports • Great Lakes Dashboard Project

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Hurricanes and tornados	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Building destruction • Flying debris • Storm surge • Tree fall (see other categories for associated intense rainfall and floods)		• Wind speed data – from local codes • International Building Code • FEMA Map Service Center
Pest infestation	Known Hazard ☐ Potential Hazard ☒ Not Applicable ☐	• Historic/facility fabric loss • Vegetation loss • Disease vectors may increase • Termites and other woodboring pests expanding range with warming and increased humidity	• USFS Forest Health Program	• Integrated Pest Management • Fisichelli et al. forest pests • USFS maps
Invasive species	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Aquatic mussels – water intakes clogged • Vegetation (kudzu, vines) – damage buildings, kill trees, obstruct waterways	• National Invasive Species Council	• Early Detection and Distribution Mapping System (current distribution) • Early Detection and Distribution Mapping System (projected distribution)

Appendix 2. What Will the Park Climate Feel Like in 60 Years?

The map below is intended to help visualize how the present-day climate in the region of **Indiana Dunes National Park** is projected to change as a result of climate change (Fitzpatrick and Dunn 2019). Under a high greenhouse gas emission scenario, Michigan City, Indiana's climate in 2080 may feel like today's

climate near Sikeston, Missouri. The typical summer in Sikeston, Missouri is 7.8°F (4.3°C) warmer and 9.3% drier than summer in Michigan City, Indiana. The red line shows the average of the 27 climate models; the black lines show the 27 individual projections assuming continued high emissions, providing a sense of the plausible range of future climates. Size of red circles give a sense of how good a match that location is, with smaller circles indicating better matches; all circles (red or purple) denote cities used in the analysis. The analysis is based on twelve climate metrics, including minimum and maximum temperature and precipitation by season (spring, summer, fall, winter). More details are available in the reference cited above and the website <https://fitzlab.shinyapps.io/cityapp/>.



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