11-12-2018

Tourism and Recreation in a Warmer Indiana: A Report from the Indiana Climate Change Impacts Assessment

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purdue.ag/tourismreport

IN CCIA
Indiana Climate Change Impacts Assessment

Our climate shapes our experiences

Indiana's climate and geography make it an attractive place for outdoor tourism and recreation. Many months of each year are ideal for boating, fishing, swimming, hiking, camping, and taking in outdoor sporting events or festivals.

But the world's climate is changing, and Indiana's is no exception. Temperature increases already seen over the last hundred years will accelerate, potentially through the end of this century, and precipitation patterns will change. Those changes will affect the many facets of tourism and recreation throughout the state, including the types of tourism the state can offer, the timing of events, and the quality of visitor experiences.

Climate change will have significant impacts on many sectors, including health, urban spaces, aquatic ecosystems, and forests – to name a few. All of these sectors are tied to the state's tourism, recreation, and hospitality industries, which rely on natural and human-built systems to create successful visitor experiences.

This report from the Indiana Climate Change Impacts Assessment (IN CCIA) uses climate projections for the state to explore likely impacts for Indiana's tourism and recreation industries. The findings presented here are primarily based on the IN CCIA Tourism and Recreation Working Group technical report (Day et al., in review), but also draw upon key findings from other reports in the IN CCIA series.

KEY FINDINGS

Significant takeaways from this report include:

Key finding: Indiana is a popular destination for hiking, camping, bird watching, cycling, and a variety of outdoor spectator sports and festivals. Shifting temperature and rainfall patterns can directly and indirectly affect the timing, enjoyment, and safety of these activities, with lasting effects on traveler perceptions.

Key finding: As Indiana's changing climate and environment affect the feasibility of, demand for, and quality of tourism and outdoor recreation, communities and businesses serving the tourism sector will need to adapt their planning and operations to leverage new opportunities that arise and to protect at-risk investments. Tourism will be impacted directly by changes in climate and indirectly by the responses of other entities to climate change. It will be essential to monitor changing environmental and social conditions across Indiana and in the locations where our visitors live as those, too, will affect the future of Indiana's tourism industry.

Key finding: Indiana's tourism and recreation businesses will increasingly face challenges related to extreme weather conditions. Heat stress events are projected to increase in frequency, magnitude, and duration. Flooding is expected to increase. Planning for these growing risks and building resilience to a changing environment will be important for the long-term success of Indiana's tourism and recreation businesses.

Key finding: As Indiana's winter season shortens by about 20 to 25 days by mid-century, and spring and fall temperatures warm 4°F to 6°F, the demand for outdoor recreation and tourism during Indiana's "shoulder" seasons is expected to increase. Shifts in the timing and suitability of shoulder-season recreation could generate more revenue for businesses during this time of year and could also require changes to operational budgets, staffing, and off-season maintenance.

Key finding: By mid-century, Indiana is projected to lose between three and four weeks' worth of mild weather per year – days when high temperatures are above 65°F but at or below 85°F. The frequency of hot days in Indiana with temperatures above 85°F, and extremely hot days with temperatures above 95°F, is expected to increase

substantially. Especially during the summer, hotter temperatures will contribute to reduced enjoyment and greater health risks for people participating in outdoor activities, including more heat-related illnesses and reduced air quality.

Key finding: Winter recreation in Indiana, including ice fishing and skiing, will be negatively affected as cold-season temperatures warm, snowfall is reduced, and rainfall is increased. Winter temperatures are projected to warm about 5°F to 6°F by mid-century in Indiana, and the annual number of days with snow cover is projected to decline by 32 to 41 percent.

Key finding: Managing parks, trails, and natural areas used for tourism and recreation is expected to become more difficult. More intense rainfall, warming temperatures, and changing streamflow patterns are expected to shift habitat suitability for plants and wildlife, increase pressure from invasive species, and alter the timing of biological events that generate tourism.

TOURISM AND RECREATION IN THE HOOSIER STATE

Indiana offers many opportunities for recreation and tourism for its own residents and those of nearby states. Lake Michigan and the Indiana Dunes anchor the northern part of the state, attracting beachgoers, anglers, boaters, and others. Indianapolis, the state's largest city, located in the central part of the state, offers cultural, culinary, and sports activities. The southern part of the state's rolling hills and forests attract outdoor enthusiasts.

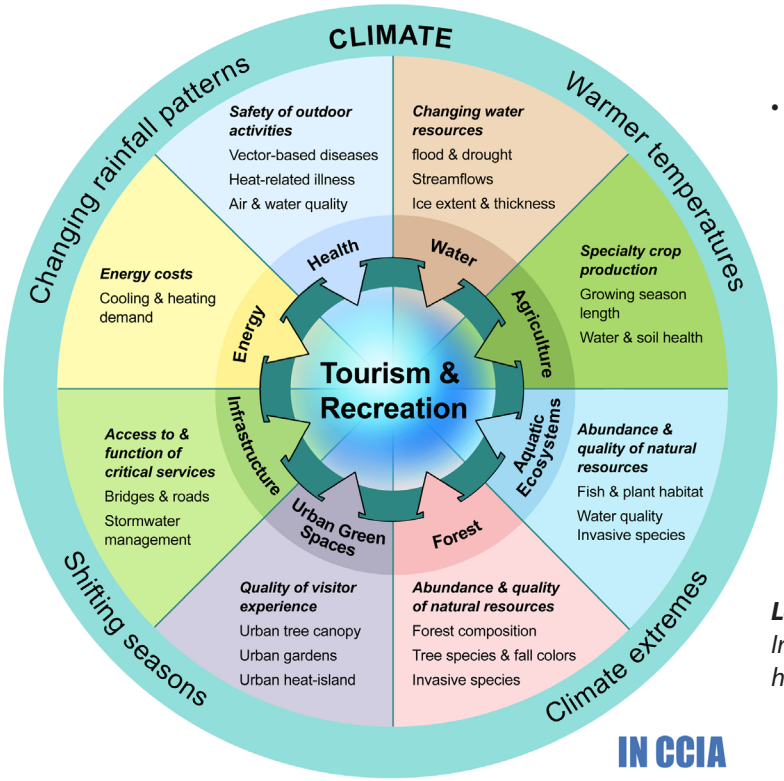
Tourism contributed $12.2 billion to the Indiana economy in 2016, directly employing more than 185,000 people[1]. More than 79 million people visited the state that year.

Tourists - those traveling more than 50 miles and staying overnight - and visitors - those who come from outside the region but only stay for the day - use many of the state's amenities, including restaurants, hotels, stores, and tourist attractions. Local residents taking part in recreation use fewer of these, but still spend money in and around their communities.

The state divides its major tourism and recreation activities into three categories:

- Culinary and agritourism: Agriculture is a significant part of the state's economy and landscape. This includes farm tours, u-pick opportunities, corn mazes, farmer's markets, and wineries, among others. Many local breweries have become attractions in recent years, and Indianapolis is a hub of the state's restaurant scene, including several farm-to-table options.
- Heritage and festivals, including arts and culture: From major attractions like Lincoln's childhood home and the Indianapolis Children's Museum to small-town charm, Indiana is a destination for Midwest heritage. In addition, its 92 counties boast more than 640 wide-ranging annual festivals and local county fairs. The Indiana State Fair in Indianapolis is also a large annual draw.
- Outdoor recreation and sport: Indiana's ties to sports and recreation are strong. The Indianapolis 500 is one of the most iconic events in sports. Professional teams and two Big Ten universities - as well as several smaller and successful universities and colleges - attract visitors to many athletic events. Indiana has also hosted the Pan American Games and a Super Bowl, and many communities attract youth sports tournaments. The state is a destination for camping, hiking, horseback riding, birding, hunting, and cycling, as well as many water activities including fishing, boating, and water sports on its many lakes and rivers.

Findings from all IN CCIA reports have implications for Indiana Tourism and Recreation



Left: *This diagram shows how information from all of the Indiana Climate Change Impact Assessment (IN CCIA) reports have relevance to the tourism and recreation sector.*

As Indiana warms and precipitation patterns change, there will be a variety of impacts on natural and human-built systems that the tourism sector and its players rely on.

Depending on the activity, temperature change could increase or decrease tourism. Extremely hot temperatures are likely to reduce the quality of warm-season visitor experiences and steer visitors and tourists to locations with milder conditions, or towards indoor activities. Warmer spring, fall or winter conditions, however, may attract those looking for places that allow for outdoor activity during those times. Increased precipitation, and more of it as rain rather than snow, could detract from Indiana's attractiveness for some popular winter outdoor activities.

Tourism and recreation are affected directly and indirectly by climate change. As such, each of the topics covered in the Indiana Climate Change Impact Assessment have implications for tourism and recreation in the state. From energy to infrastructure and health to hydrology, as each sector is affected by climate change there will be cascading impacts on tourism and recreation.

Tourism is both complex and adaptive. Complex because many different players – hotels, attractions, stores, and transportation – all come together to create a visitor experience. But the tourism and recreation system is also dynamic, and each player within it will need to adapt to the direct and indirect impacts. Heightened awareness of climate change is important for businesses preparing for the new challenges.

INDIANA'S CHANGING CLIMATE

Changes in climate will broadly affect Indiana's tourism sector – directly by affecting outdoor conditions that tourists experience, and indirectly by affecting everything from the types of food that can be grown in the state to water quality, forests, infrastructure, and health. Each has ties to tourism and recreation.

Indiana's average annual temperature has already warmed 1.2°F over the last century, and the temperature rise has accelerated in recent decades. By the middle of the 21st Century, Indiana's annual temperature is expected to increase by 5°F to 6°F, and by century's end that increase could reach 10°F[2].

Over the last century, Indiana's average annual precipitation has increased 5.6 inches, or about 15 percent, and more rain is falling in heavy downpours. Projections show annual precipitation increasing 6 percent to 8 percent by mid-century and as much as 10 percent by the end of the century[3], with more frequent heavy downpours. Winters and springs are likely to be much wetter by mid-century, while expected changes in summer and fall precipitation are less certain[4].

Warm season averages and extremes

As temperatures increase, Indiana will see a growing number of warm days with temperatures above 65°F, but with notable shifts in the occurrence of mild, hot and extremely hot days. Mild-weather days are defined as those in which the high temperature is above 65°F but at or below 85°F - essentially, warm enough to be outdoors but not uncomfortably hot. These days are ideal for tourism, and there will be many fewer of them experienced each year as the occurrence of hot and extremely hot days increases.

Projected Changes in Indiana's Temperature

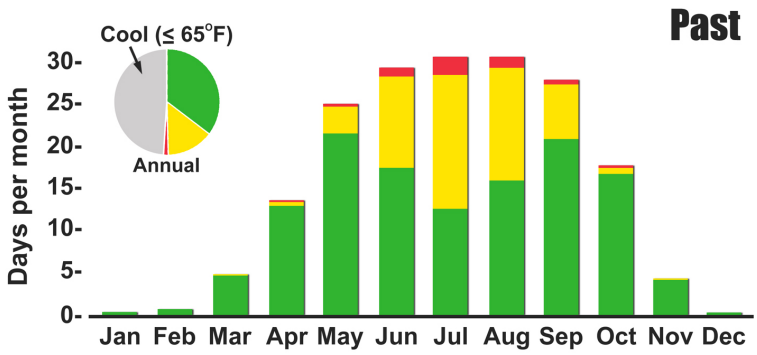
Scenario	Period	Winter	Spring	Summer	Fall	Annual
Medium Emissions	2020s	2.9°F	2.6°F	3.0°F	3.3°F	2.8°F
	2050s	4.9°F	4.2°F	5.1°F	5.1°F	5.1°F
	2080s	5.9°F	5.1°F	6.7°F	6.2°F	5.8°F
High Emissions	2020s	3.1°F	2.4°F	3.3°F	3.2°F	3.4°F
	2050s	6.2°F	5.1°F	7.0°F	6.5°F	6.2°F
	2080s	10.0°F	8.2°F	11.8°F	10.9°F	9.4°F

Above: *Projected annual and seasonal temperature change for Indiana compared to the historical period (1971 to 2000). Values represent state-level averages from 10 climate model projections. For the future projections, "2020s" represents the average from 2011 to 2041, "2050s" represents the average from 2041 to 2070, and "2080s" represents the period from 2071 to 2100. Source: Hamlet et al. (in press).*

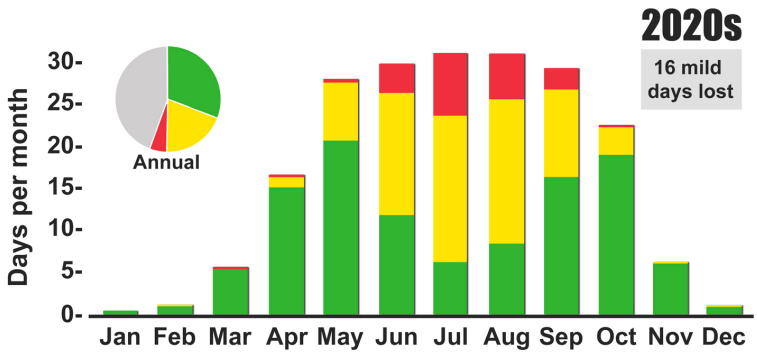
Hoosiers Heating Up

Number of mild, hot, and extremely hot days in Indiana

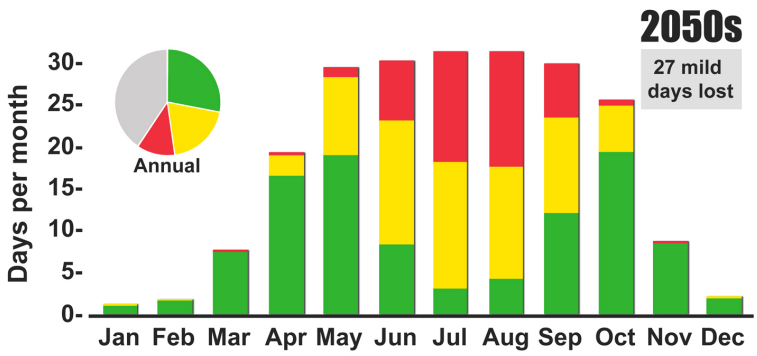
Mild (> 65°F and ≤ 85°F)
Hot (> 85°F and ≤ 95°F)
Extreme (> 95°F)

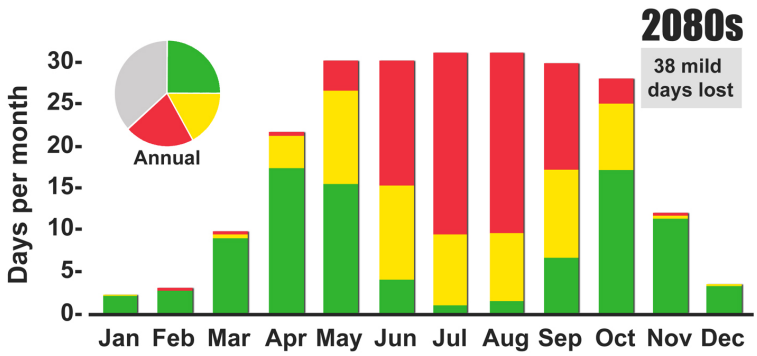


Mild days decline, shoulder seasons shifts — comfortable days from May to Sept are replaced with hot and extremely hot days. Months with predominantly mild weather will start earlier and end later in the year.



Summer heat on the rise, lasting longer — extremely hot days dominate summer months by end of century. Hot weather days in spring and fall increase.





"Past" is an average for the period 1915 to 2013. "2020s" represents the average 30-year future period 2011 to 2040. "2050s" represents the average 30-year period 2041 to 2070. "2080s" represents the 30-year period 2071 to 2100. Future projections are based on average results from 10 climate models based on a **high-emissions scenario** (Hamlet et al., in press).

IN CCIA
Indiana Climate Change Impacts Assessment

Above: *Projected number of mild, hot, and extremely hot days in Indiana by month (stacked bars) and annually (pie chart) for the historical period (1915 to 2013) and three time periods in the future based on a high-emissions scenario. For the future projections, "2020s" represents the average from 2011 to 2041, "2050s" represents the average from 2041 to 2070, and "2080s" represents the period from 2071 to 2100. Data for other locations and emissions scenarios available.*

Statewide, Indiana has historically (1915 to 2013) experienced, on average, 129 mild days each year, with little variation in the annual total across the state. But by the middle of the century, Indiana is expected to lose 22 to 27 of its mild days per year, depending on the amount of heat-trapping gases put into the atmosphere. By the end of the century, Indiana may lose as many as 38 mild days. These losses will be greatest in the summer months (June-August), which will lose more than half of their mild days by mid-century, and potentially almost two-thirds under higher emissions. Mild days are expected to increase, however, during the shoulder seasons (March, April, October, and November), which could increase demand for recreation during these times of the year.

The number of hot days, defined as days with temperatures above 85°F but at or below 95°F, will increase. Historically, Indiana would experience about 52 of these days each year, ranging from about 42 days annually in the north to about 65 days in the south. Projections show hot days increasing statewide, with the largest increases in the north where mid-century projections show 24 to 25 more hot days annually compared to the past. In southern Indiana, hot days are expected to increase by 10 to 15 per year.

Extremely hot days, in which the temperature is above 95°F, will also increase significantly, especially impacting the southern portion of the state. Temperatures above 95°F increase the likelihood of heat-related illnesses and can reduce the amount of time a person will spend outdoors. That would be problematic for outdoor and sports tourism and recreation. Historically, southern Indiana has experienced seven of these extremely hot days per year. By mid-century, it can expect 38 to 51 of them per year.

In addition to more frequent heat, the average length of heat stress events (consecutive days with temperatures above 86°F) is expected to double, from 3 days in the past, on average, to 6 to 8 days by mid-century[5].

Air quality also declines as temperatures rise. Increased temperatures are linked with creation of more ground-level ozone, a lung irritant that can trigger asthma attacks and other acute cardiovascular and respiratory problems. Poor air quality days limit outdoor time for those who are sensitive to or suffer from some of these issues.

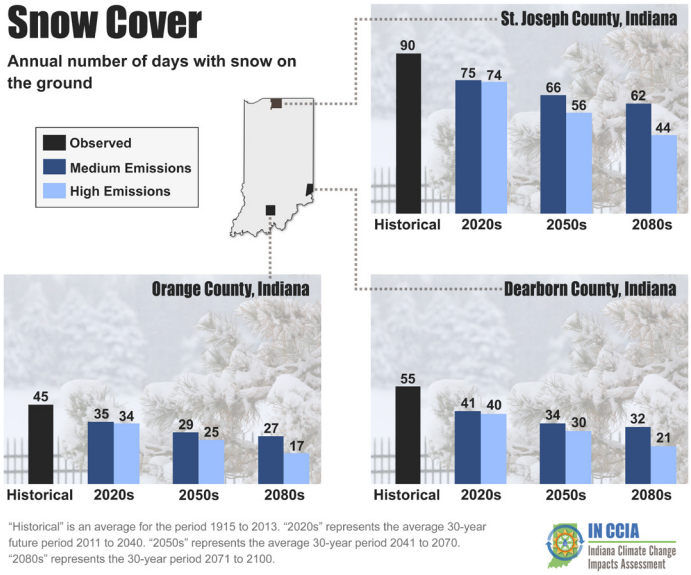
Warmer days will be accompanied by more uncomfortable nights in which the low temperature stays above 68°F. Paired with high humidity, these conditions put added stress on individuals prone to heat-related illnesses or respiratory illnesses associated with poor air quality. Warm nights can also affect crop production, the spread of pests and diseases, and other events in nature. Whereas Indiana has historically experienced 10 to 40 of these nights per year based on location, some places may see over 100 nights per year by the end of the century.

Rising humidity, paired with hot temperatures, will make being outdoors increasingly uncomfortable, too. The wet bulb index—measured in degrees Fahrenheit—takes into account temperature and humidity, and is one way to measure outdoor discomfort for humans and animals. Periods with a wet bulb index above 80°F are very uncomfortable and feel like the hottest summer months in humid parts of Texas and Louisiana. By the middle of this century, Indiana could experience 10-30 days in which the wet bulb index reaches 80-86°F, up from 10 or fewer between 1981 and 2010.

Cold season averages and extremes

Temperatures during cool and cold months will also rise. The average coldest night of the winter in Indiana is expected to rise by about 6°F by the mid-21st Century.

Cold days, defined as days in which the daily minimum temperature is below 5°F, and frost days, defined as days in which the daily minimum temperature is below 32°F, are also expected to decline. Climate projections suggest that northern Indiana could move from 15 cold days per year to as few as three per year.



Above: *Average annual number of days with snow cover for three Indiana counties, including the two southern counties that host commercial ski areas. "Historical" is an average for the period 1984 to 2013. For the future projections, "2020s" represents the average of the 30-year period from 2011 to 2040, "2050s" represents the average from 2041 to 2070, and "2080s" represents the average from 2071 to 2100. Source: Cherkauer et al. (in preparation).*

Those rising temperatures mean that much less precipitation in the winter will fall as snow. In southern Indiana, there will be little precipitation falling as snow by the late 21st Century, and instances of snowfalls of 2 inches or more will be quite rare. Throughout the state, snowfalls that total 2 or more inches will happen about half as often by the end of this century.

Recent research examined several winter climate metrics relevant to the tourism and recreation industry and how they are expected to change throughout this century (Chin et al., 2018). Indiana's winter is projected to shorten by 20 to 25 days by mid-century, and up to 44 days by late-century[6]. The number of days suitable for snowmobiling, where snow depths are at least 6 inches, is projected to decline from 16 days historically to five to seven days by mid-century and as few as three days by late-century. The number of days with temperatures suitable for artificial snowmaking is expected to decline from 18 days historically to nine to 10 days by mid-century and as few as five days by late-century[7].

WATER-BASED RECREATION

Boating, swimming, watersports, and fishing are popular pastimes on Indiana's lakes and rivers. Freshwater recreation contributes more than $1 billion annually to the state's economy.

Wetter winters and springs expected in Indiana will increase the risk of flooding, threatening environmental quality and human safety. Heavier rains could increase the number of combined sewer system overflows, dumping raw sewage into nearby rivers. These issues would reduce the ability of swimmers, anglers, and boaters to safely use Indiana's rivers and lakes for recreation. Flooding and increased precipitation could lead to more standing water, which would increase mosquito populations and the risk of mosquito-transmitted diseases.

Conversely, hotter, drier summers could lead to lower water levels on lakes popular for swimming and boating, either from direct water reductions (low rainfall, high evaporation) or from changing water management required to meet the needs of competing water interests (including agriculture, drinking water supply, and environmental protection).

Traditionally, lifeguards are only kept on staff until Labor Day, or even earlier – some community pools close when their guards have to go back to school in August. As warmer autumn air and water temperatures enable a longer swimming season, more people may be prevented from swimming or enter unguarded waters unless staffing schedules are adjusted.

More rainfall can increase farm field nutrient runoff, which takes fertilizers such as phosphorus and nitrogen to nearby streams and other waters. That may lead to more algal blooms that degrade water quality and affect fish populations. Warmer conditions can also lead to blooms of some harmful cyanobacteria, microscopic organisms that can release toxins.

Water temperature changes in lakes will also affect fish populations. Warmer water will reduce habitat availability and push some coldwater species to lower waters in deeper lakes. Dead algae that falls to the bottom of lakes will be consumed by bacteria, leading to loss of oxygen at lower water levels. Those coldwater fish species will be squeezed out and may decline in numbers, which would reduce opportunities for anglers. (View list of Indiana fishes threatened by habitat reductions from warming water temperatures.)

LAND-BASED ACTIVITIES

Many outdoor activities done on land are likely to be impacted by climate change. Hotter temperatures will make being outdoors in summer not only more frequently uncomfortable, but sometimes dangerous. And increases in spring precipitation and associated flooding will make some outdoor activities such as canoeing impossible at times. Tourism organizations and recreation service providers will need to adapt to these changes. Business continuity and activities to increase business resilience will be important.

Changing patterns of plant growth and other biological events (e.g. animal migrations, flower blooms, insect emergence), and increased threats from invasive species are likely to create challenges for natural resource managers. Increased costs to deal with changing management needs could become an issue for many recreational areas.

Heat may make hiking, camping, and other outdoor activities popular in the forested southern part of the state less attractive. A warmer climate will also likely shift migration patterns of birds and other fauna that could alter the area's attractiveness for bird watching and hunting. According to the National Audubon Society, over 300 North American birds are at risk from climate change as summer and winter habitat ranges are altered.

The arrival of Indiana's stunning fall foliage is highly influenced by summer and fall temperatures and rainfall

patterns. Generally, warmer temperatures will delay the onset of color, as will above-normal rainfall. However, heat stress from extremely high temperatures and water stress from either flooding or drought can cause the foliage season to start earlier and dull leaf coloring. Additionally, some of Indiana's more colorful trees, such as northern red oak and sugar maple, are projected to have decreased habitat suitability in central and southern Indiana by the end of the century.

Ticks and mosquitoes, whose populations and ranges are inhibited by extreme cold events, are more likely to flourish as temperatures rise and their populations are better able to survive the winter. Outdoor enthusiasts will need to be more aware of the potential for tick-borne illnesses such as Lyme disease, and mosquito-borne illnesses such as West Nile virus, Zika, and others.

AGRITOURISM

Indiana's agricultural identity is strong. A significant part of that is in specialty horticultural crops such as berries, apples, and grapes, which also support agritourism throughout the state. Climate change will play a role in how well those crops fare in the future. As long as farms continue to provide agritourism, visitor experiences are unlikely to be significantly affected. However, farm owners will need to adapt their operations, including planting different crop varieties, to withstand changes in future climate.

Many perennial crops need low temperatures for certain amounts of time to begin winter dormancy. A warming climate may mean those necessary periods aren't always achieved, leaving some plants vulnerable to cold snaps. Early springs could also leave other crops vulnerable to late frosts. Some fruit plants will no longer be suitable for Indiana or may be severely damaged more often, reducing yield and profits for growers. In other cases, Indiana's climate may allow the expansion of warmer-climate crops into more of the state.

Popular apples, such as Golden Delicious and Honeycrisp, may no longer be viable in Indiana later in the century. They could be replaced by others, such as Braeburn, Fuji, and Gala.

Warmer temperatures could allow for expansion of peaches, pluots, and nectarines, as well as some berries, such as boysenberries and tayberries. Grape growers may be able to move from some of the hybrids required to survive cold winters to less-hardy Vitis vinifera varieties, such as chardonnay and pinot noir.

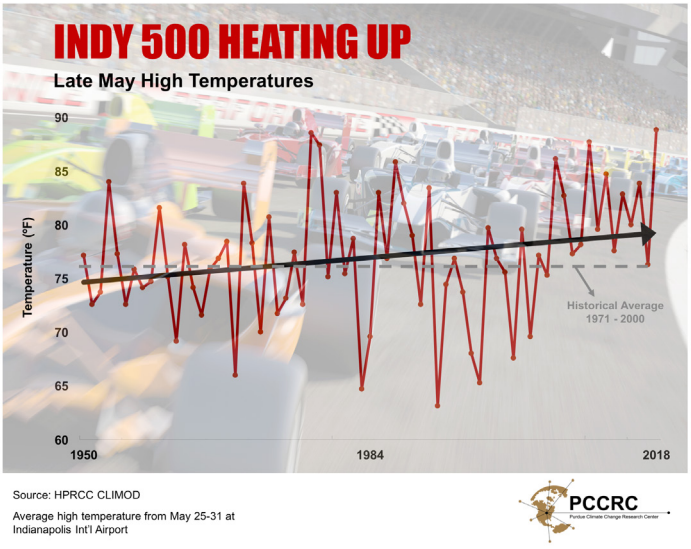
SPORTS AND EVENTS

Many athletic events occur outdoors. Rising heat and changes to precipitation patterns may push some events out of Indiana or change their timing. Indoor facilities may be necessary to support some events, and event facilities may need additional investments in heat-reducing infrastructure such as air conditioning or shaded areas.

Youth baseball, which often occurs in the spring and summer months, may start its season earlier to avoid hot or extremely hot temperatures in late spring and summer, but may need to account for more rainouts as spring precipitation increases. Football practices, which currently begin in late summer, may need to be pushed to later in the year to account for heat. These factors may make Indiana a less-attractive option for hosting youth tournaments during these times of year.

The Indianapolis Colts play indoors, making climate essentially irrelevant. But Indianapolis is home to a thriving racing scene. The Indianapolis 500 is considered one of the most famous car races in the world. And NASCAR's Brickyard 400 has in the past drawn as many as 200,000 fans.

The Brickyard 400 has traditionally run in the last week of July. But already blistering temperatures caused NASCAR to move the race in 2017 to early September for the first time. The president of the Indianapolis Motor Speedway told the Indianapolis Star (Ayello and Keefer 2017) that fans had been complaining that the July heat made the race less enjoyable.



Above: *This graphic shows the average high temperatures from May 25 to May 31 in Indianapolis from 1950 to 2018 (red line). The black solid line shows the increasing temperature trend over time and the gray dashed line shows the 30-year average temperature. Data were accessed from the High Plains Regional Climate Center CLIMOD Database.*

The Indy 500 is also dealing with increasing heat. While the historic average high for the last week of May, when the race is held, is about 76°F, recent years have been warmer. The average temperature for race week is about 3.5°F higher today than in 1950. At the 2018 event, the temperature on race day reached 91°F and about 200 people at the race were treated for heat-related illnesses, according to the Indianapolis Star (Tuohy et al., 2018).

WINTER TOURISM AND RECREATION

Rising temperatures, less winter precipitation falling as snow, a shortened winter season, and fewer days with snow cover will be significant problems for winter tourism and recreation in Indiana.

Indiana is home to two ski resorts, both in the southern portion of the state. Reductions in snowfall mean these businesses will need to rely more on making their own snow, but that will be difficult to maintain with warmer air and ground temperatures. Snowshoeing, cross-country skiing, and snowmobiling will likely see declines as days with snow cover and snow-cover depths decline. These winter activities that depend on snow will become less viable over time.

Reduced ice cover (both duration and thickness) may reduce opportunities for ice fishing on Indiana's inland lakes. Indiana-specific ice cover trends and projections are not available. However, recent studies of the ice cover season throughout the upper Midwest show observed delays in ice onset and earlier ice melt, and projections show this trend continuing and intensifying throughout this century (Hewitt et al., 2018). Outdoor skating rinks will likely see fewer days with temperatures cold enough to support ice. And those skating on lakes and ponds will need to be increasingly aware of the risks associated with skating on ice that may typically be thinner than it was in the past.

Winter in Indiana is also associated with maple syrup and Christmas trees.

Indiana's maple syrup production, around 10,000 gallons' worth each year, is dependent on the weather. Warmer winters will reduce the amount of time syrup can be produced. Tree farms, some of which create an experience by letting visitors choose and cut their own trees, may see some tree species, such as white pine, decline because of warming temperatures.

RESPONDING TO CHANGE

Tourists will continue to visit places that offer enjoyable and interesting experiences. They may determine that activities for which they once traveled to Indiana may no longer be as enjoyable, or may shift to a different time in the year, based on the state's climate.

The success of Indiana's visitor and tourism industry will depend, in part, on how businesses, government, and others adapt. Monitoring consumer demand will be critical to keeping people interested in coming to Indiana for recreational opportunities.

The players involved in the state's tourism industry can only adapt if they are aware of how Indiana's climate is changing and how it might affect them. Interviews with tourism and recreation businesses in northern Indiana found that businesses have strong awareness of how weather and climate affects them, and many can describe potential climate change impacts, but few were doing anything to prepare (Chin 2016). Lack of preparedness was attributed to limited resources, lack of knowledge about adaptation options, and uncertainty about the necessity to adapt (Chin 2016).

Some businesses are used to making quick operational decisions based on weather - for example, water parks often close when there are storms on the horizon. But those business owners need to take into account how climate will affect their operations over the long term. Warm-weather destinations may consider opening earlier in the spring, but they must also be cognizant of the increased likelihood of strong and more frequent precipitation during that period. Businesses may need to factor in rising costs in some areas, such as the need for more cooling during summer months.

Some businesses, such as fishing tour operators on Lake Michigan, have shown an ability to adapt by changing the types of fish they seek out based on changes to climate. Increased dialogue about likely impacts and potential solutions can help Indiana's tourism and recreation sector build resilience in the face of climate change.

Taking a wider view, whole communities and regions of the state will need to consider the ramifications of climate

Preparing for Change

The following are five ways that communities, businesses and individuals can prepare for climate change.

- Everyone: Be aware of the climate changes and the impacts it will have on you, your business and your community.
- Local government/planners: When developing long-term infrastructure and services, consider the impacts of climate change as well as the needs of visitors and tourists during the planning process. These important topics are often overlooked in long-term planning.
- Businesses: Monitor change and adapt as necessary. Make "no regrets" changes in your business – decisions that are good even if the worst scenarios don't happen.
- Businesses: Plan for risk and become resilient. Build your capacity to respond to, and recover from, challenges like tornadoes or heat waves.
- Individuals: Be aware of your impact on the environment and climate change when you travel. Travel responsibly.

change for their abilities to continue to attract tourists. Infrastructure, including roads, water and sewage piping, and energy generation, will need to be considered when planning for future tourism.

Developers planning new attractions should also be cognizant of how their investments will fare as climate changes. What is attractive in today's climate may lose its appeal in the coming decades as mild weather becomes less common.

KEY KNOWLEDGE GAPS

While research on the impacts that climate change will have on tourism is ongoing, there are still many unknowns, especially related to human behavior. It's unclear if, how, and when society will respond to climate change when making travel plans. Little is known about how players in the tourism industry will monitor climate change and its potential impacts and how they will be able to adapt. Building more understanding about how businesses respond to risk and how policies that address climate change affect the tourism sector will be important.

CONCLUSIONS

Indiana's changing climate will have direct and indirect effects on the natural and human-built systems that support Indiana's thriving tourism and outdoor recreation sector. As temperatures warm and seasons shift, the times of year suitable for outdoor experiences, and the satisfaction from those experiences, will be altered. Changing rainfall patterns are expected to bring a range of impacts including safety issues, altered access to water bodies, and activities being rained out. Ultimately, the businesses and communities providing visitor experiences will need to increase their awareness of the far-reaching impacts of shifting climate so they can increase their resilience in the face of change.

Tourism System Actor	Response Time Horizon		
	Short	Medium	Long
Visitor / Tourist	Travel elsewhere		
Small Business	Operational response	Facility updates, new construction	
Developer		Facility updates, new construction	New construction
Community / Infrastructure Supplier			Infrastructure development (roads, energy, water)

Above: *Tourism stakeholders responsiveness to weather and climate.*

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END NOTES

[1] *Data based on analysis from the Indiana Office of Tourism Development available at http://www.visitindianatourism.com/why-tourism-matters*

[2] *Projected change in temperature averaged across 10 climate models for two scenarios of heat-trapping gas emissions based on analysis by Hamlet et al. (in press) and Widhalm et al. (2018). Mid-century refers to the 30-year period from 2041 to 2070. Late century refers to the 30-year period from 2071 to 2100. Future temperature changes are relative to the statewide annual average temperature from 1971 to 2000. Further details provided in Widhalm et al. (2018).*

[3] *Projected change in precipitation averaged across 10 climate models for two scenarios of heat-trapping gas emissions based on analysis by Hamlet et al. (in press) and Widhalm et al. (2018). Mid-century refers to the 30-year period from 2041 to 2070. Late century refers to the 30-year period from 2071 to 2100. Future precipitation changes are relative to the statewide annual precipitation from 1971 to 2000. Further details provided in Widhalm et al. (2018).*

[4] *Ten different climate models are used to look at Indiana's future climate. There is high agreement across these models when looking at Indiana's future precipitation during the winter and spring months as well as annually. There is low agreement across these models when looking at Indiana's future precipitation during the summer and fall months. For more information, see https://ag.purdue.edu/indianaclimate/a-range-of-possible-future-climates/*

[5] *Future changes are relative to the historical period 1981 to 2010. Range of future projections based on medium- and high-emissions scenarios.*

[6] *Length of winter is defined as the number of days between the first and last occurrence of at least 6 days with a daily average temperature of less than 41°F.*

[7] *Days where the maximum temperature is less 28°F is considered suitable for artificial snowmaking.*

HOW TO CITE

Day, G.J., Widhalm, M., Chin, N., Dorworth, L., Shah, K., Sydnor, S., and Dukes, J.S. 2018. Tourism and Recreation in a Warmer Indiana: A Report from the Indiana Climate Change Impacts Assessment. Purdue Climate Change Research Center, Purdue University. West Lafayette, Indiana.
DOI: 10.5703/1288284316814

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ACKNOWLEDGEMENTS

We thank Brian Wallheimer for drafting this report, Stan Coffman for assistance with graphics, and staff from Purdue University's Department of Agricultural Communication, including Andrew Banta, Steve Doyle, Morgan Grosso, Maureen Manier, Russell Merzdorf, and Erin Robinson for help with the production and release of the report. Thank you to Scott Robeson at Indiana University for data analysis support. We are grateful to Nina Collins and Marcia Wilhelm-South from the Purdue University Libraries Scholarly Publishing Division for online publication support for all documents associated with the IN CCIA.

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Nov. 2018