Section 7. Climate Change in Arkansas

Introduction

In the last several years, evidence suggesting detrimental effects from changing climate patterns has increased and stirred concern within the conservation community. In 2010, Arkansas cited climate change as an emerging threat to species and habitats within the Arkansas Wildlife Action Plan (AWAP). The incorporation of climate change into the AWAP, as part of the required revision process, is a recommended best practice from The Association of Fish and Wildlife Agencies (AFWA 2012). Incorporating climate change into the AWAP provides us an opportunity to be proactive in our approach, consistent with other state's wildlife action plans and efforts, and to be included in funding opportunities that may arise for addressing climate change impacts. This chapter will provide a general overview of climate science, a synopsis of projected changes to Arkansas's climate, a discussion of anticipated impacts to Arkansas's habitats and species of greatest conservation need, and a strategy to adapt to predicted changes.

Background

In regards to climate change, it is important to understand the distinction between climate and weather. Weather is a set of the meteorological conditions for a given point in time in one particular place, while climate is the average, long-term (30 years or more) meteorological conditions and patterns for a geographic area (Brandt and others 2014). Climate change is defined as a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, that persists for an extended period, and that is attributed to either natural variability or human-related activities (IPCC 2007).

Analyses of climate data from as long ago as 1880, show that the Earth's surface temperature has increased by more than 1.4°F over the past 100 years, with much of the increase taking place over the past 35 years (National Research Council 2012). Warming temperatures are often attributed to an increase in greenhouse gas emissions, particularly carbon dioxide, which increased 80% between 1970 and 2004 (IPCC 2007).

To model future climate change, scientists utilize various general circulation models (GCM). Climate change analysis becomes more complex for the future than the past because there is not one time-series of climate, but rather many future projections from different GCMs run with a range of CO^2 emissions scenarios (IPCC 2007). It is important not to analyze only one GCM for any given emission scenario, but rather to use ensemble analysis to combine the analyses of multiple GCMs and quantify the range of possibilities for future climates under different emissions scenarios. Human population growth and related greenhouse gas emissions and changes in land cover have been modeled under various scenarios in order to project future trends for global temperature and precipitation.

SRES refers to the scenarios described in the IPCC Special Report on Emissions Scenarios (IPCC 2007). The SRES scenarios are grouped into four scenario categories (A1, A2, B1 and B2) that characterize various urban development pathways, covering a wide range of demographic, economic and technological driving forces and resulting GHG emissions. These emissions projections are widely used in the assessments of future climate change.

Under the A2 scenario, we see rapid economic growth, a global population that peaks in mid-century and no reduction in emission levels. The B1 scenario also describes a global population that peaks mid-century, but with a shift toward sustainable energy and a significant reduction in global emissions. The A1B scenario describes a moderate reduction in emissions levels.

Projected Changes for Arkansas

The Nature Conservancy's climate wizard is a widely accepted, interactive web tool that incorporates data from IPCC climate models and can be used to assess how climate has changed over time and to project what future changes are likely to occur in a given area. It uses a non-parametric quantile-rank approach that maps out the 0 (minimum), 20, 40, 50 (median), 60, 80, and 100th (maximum) percentiles. Here we display maps produced by the Climate Wizard for changes in mean temperature and precipitation for Arkansas using an ensemble of GCMs and the 3 more widely accepted emissions scenarios (A2, A1B, and B1) for 50 years into the future (Girvetz and others 2009).

Temperature

Historical average temperature for Arkansas ranged from 58 to 63 degrees between 1895 and 2013 (Figure 7.1).

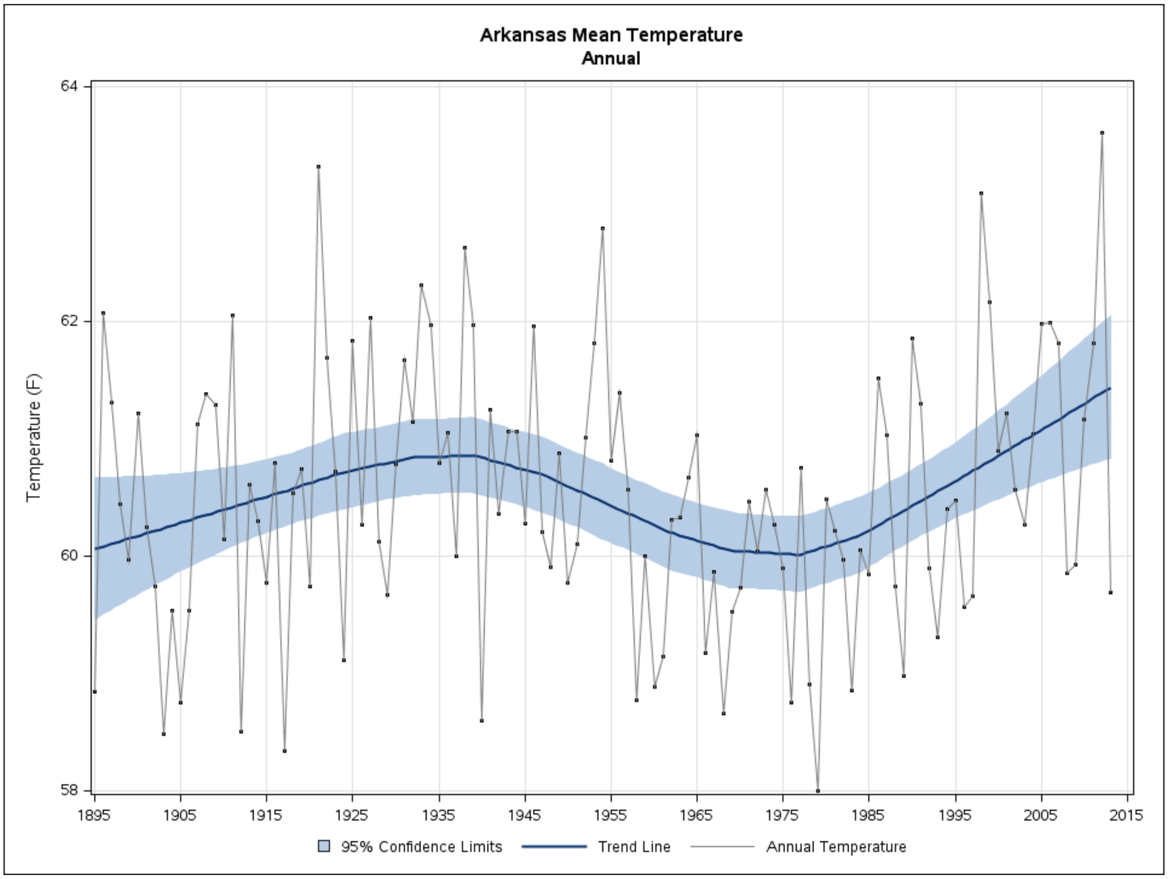

Figure 7.1. Mean annual temperature for years 1895-2013 for Arkansas. Map produced by NOAA Climatic Data Center.

Average annual temperature by mid-century (2050) is expected to increase under each emissions scenario. The most significant increase is predicted under the moderate emissions scenario (5.1°F). Under this scenario, the change in temperature is more widespread across the state (Figure 7.2). Under the high emissions scenario, an average increase of 4.9°F is anticipated, with a higher increase in the northwest part of the state (Figure 7.3). Even with a dramatic decrease in emissions under the B1 scenario, the average annual temperature is predicted to increase by 3.6°F (Figure 7.4).

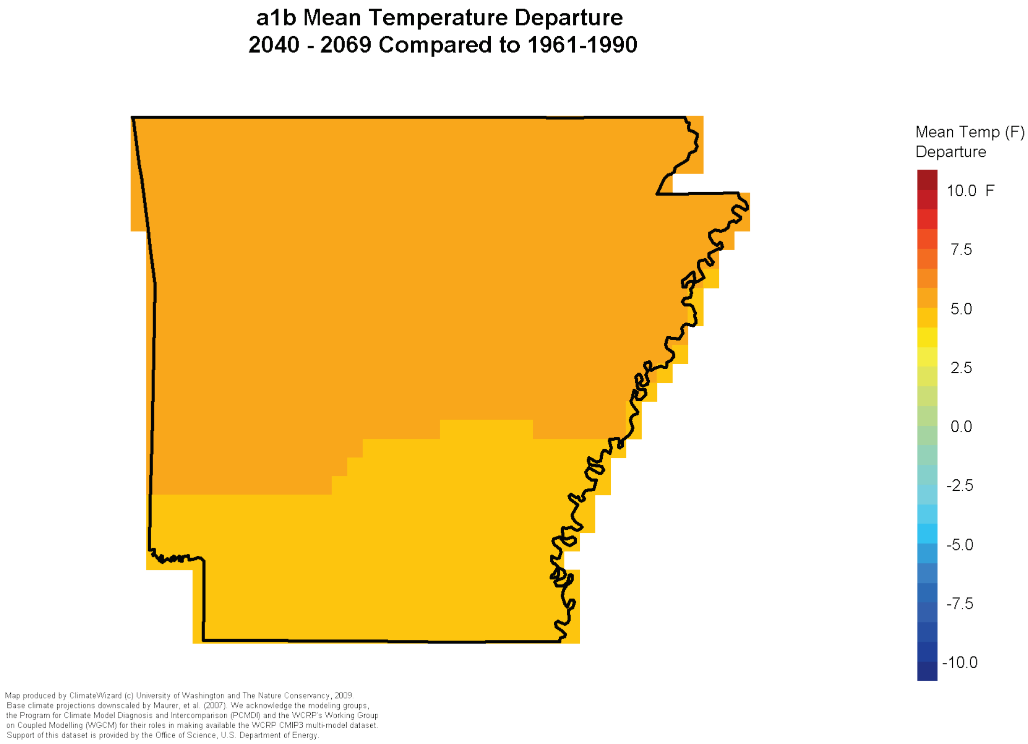

Figure 7.2. Predicted change in mean temperature in the next 50 years for Arkansas under the moderate emissions scenario (A1B).

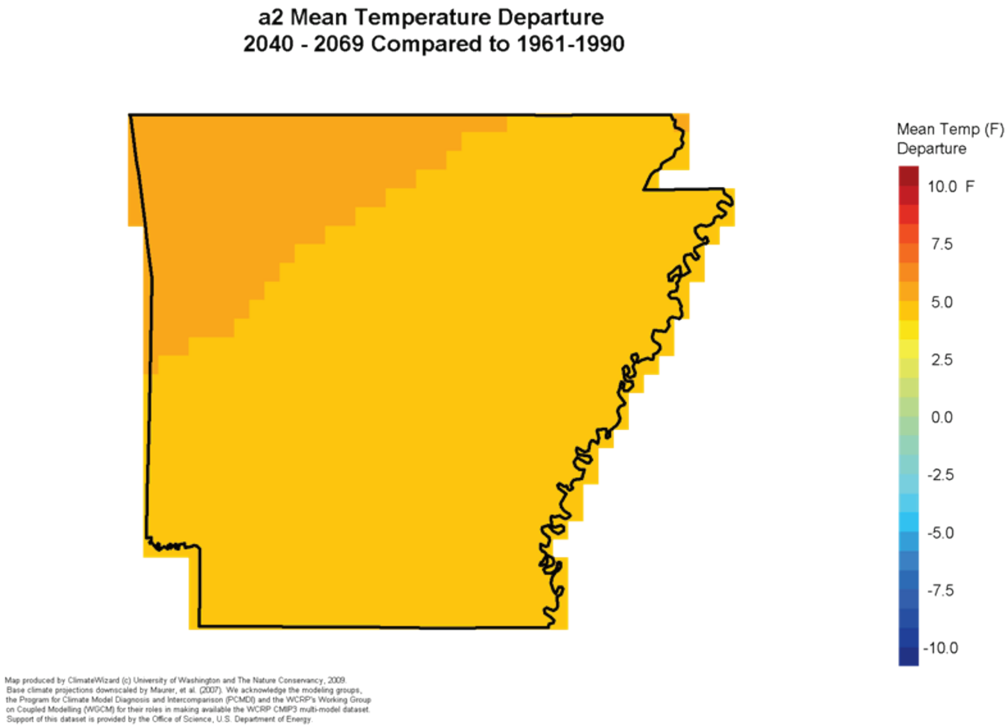

Figure 7.3. Predicted change in mean temperature in the next 50 years for Arkansas under the high emissions scenario (A2).

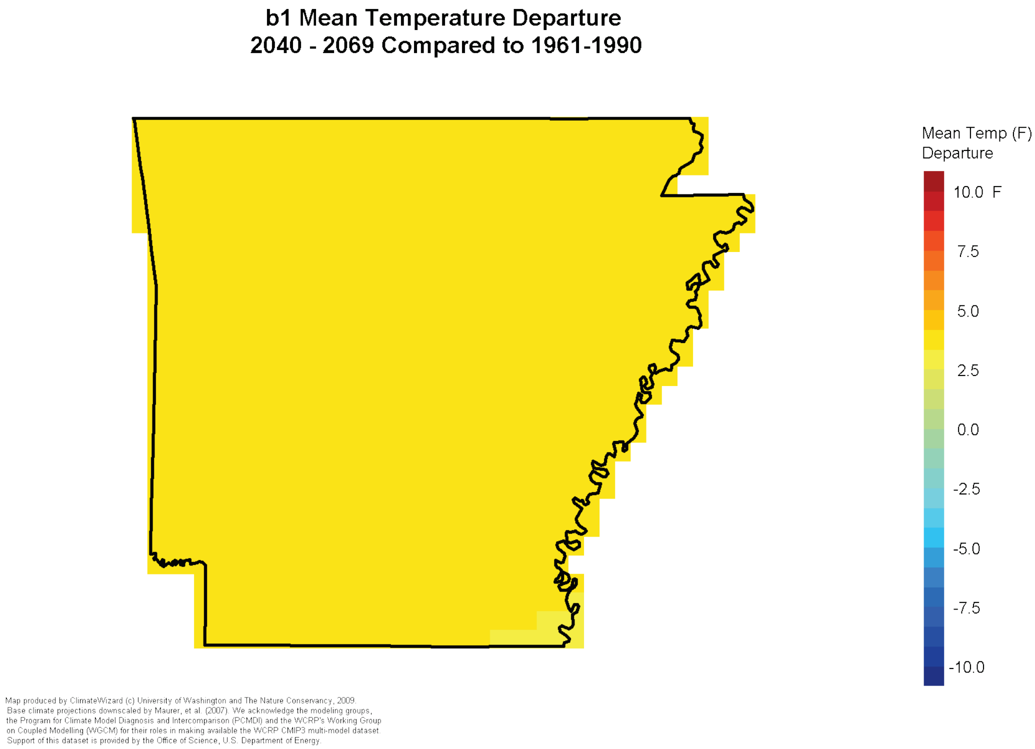

Figure 7.4. Predicted change in mean temperature in the next 50 years for Arkansas under the low emissions scenario (B1).

Precipitation

The average annual precipitation for Arkansas from 1951 to 2006 was 49.4 inches. During this timeframe, the average increased by a rate of 0.101% per year. Global predictions for precipitation changes into the future point to an overall decrease. This may be because the Southeast is located in the transition zone between projected wetter conditions to the north and drier conditions to the southwest. The average change in precipitation for Arkansas by mid-century is predicted to be +1.65%, - 0.79%, and +1.74% under the A2, A1B, and B1 scenarios, respectively (Figures 7.6, 7.7, and 7.8). Under each scenario, the southern portion of the state would see the greatest decrease in precipitation. Though there is uncertainty among the scenarios in projected precipitation amounts, rising temperatures will account for an increased rate of evapotranspiration, and a decrease in available water (Kunkel and others 2013, Carter and others 2013). Further, climate change models project that precipitation will be produced in fewer and heavier rainfall events. If so, this could lead to a decrease in aquifer recharge because more rainfall would be lost to runoff and could also result in an increase in both drought and flooding events. The southeast region is thus predicted to see a significant reduction in water availability (Carter and others 2014).

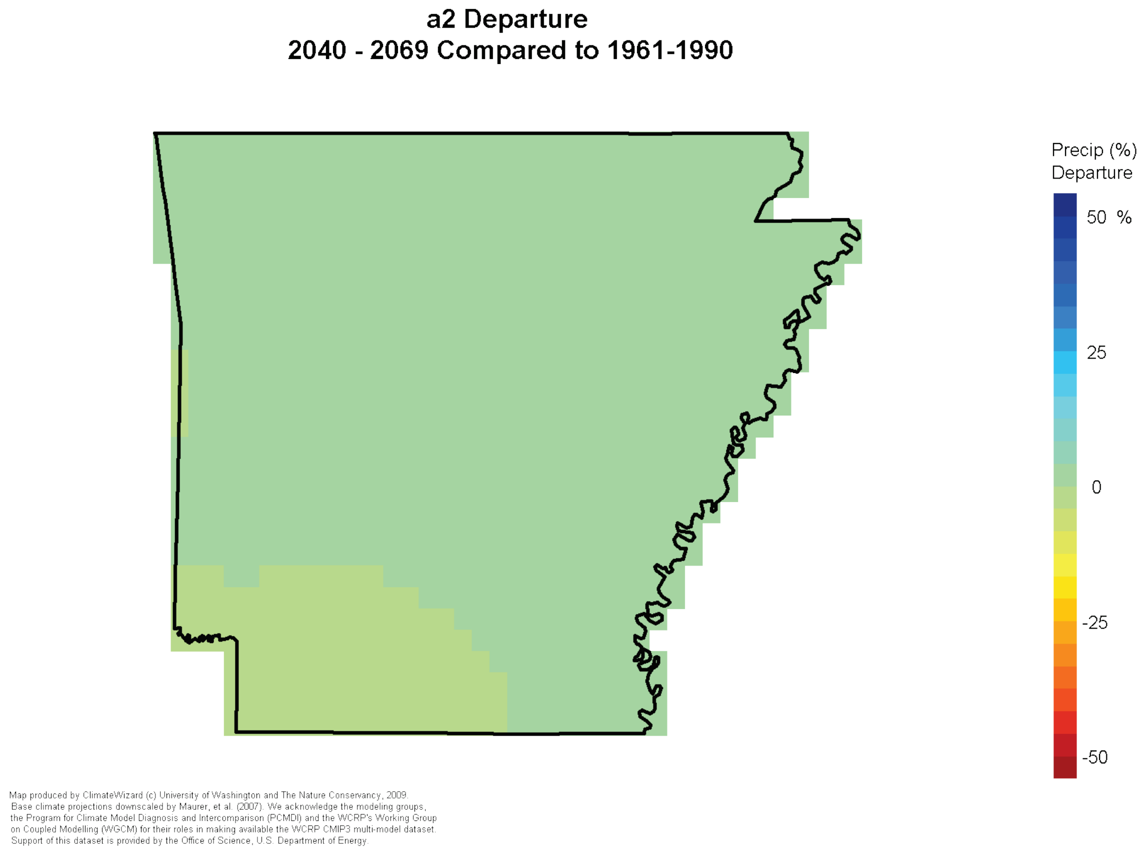

Figure 7.5. Predicted change in mean precipitation in the next 50 years for Arkansas under the high emissions scenario (A2).

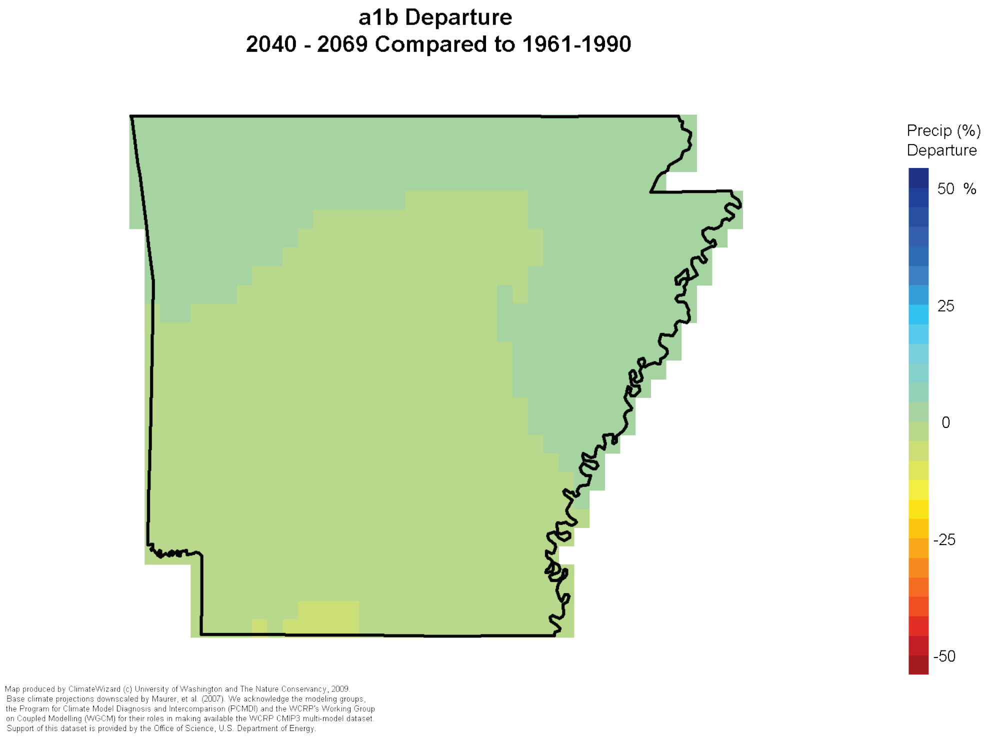

Figure 7.6. Predicted change in mean precipitation in the next 50 years for Arkansas under the moderate emissions scenario (A1B).

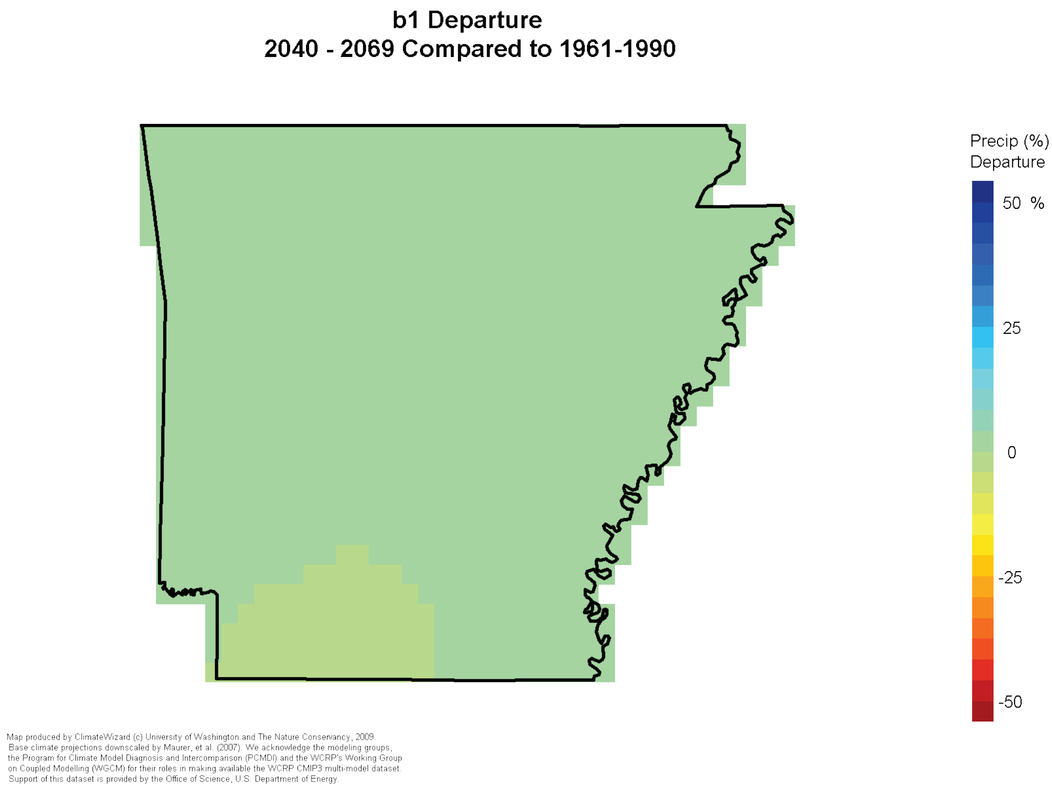

Figure 7.4. Predicted change in mean precipitation in the next 50 years for Arkansas under the low emissions scenario (B1).

Potential Impacts to Habitats

The Arkansas Wildlife Action Plan identifies 37 terrestrial and 18 aquatic habitat types that occur within the state. These habitats are threatened by many factors, including fire suppression, habitat alteration and fragmentation, invasive species, and diversion of water. Changes to climate could potentially exacerbate existing threats within many habitats.

Terrestrial Habitats

With an anticipated increase in temperature and overall drier conditions, habitats that are drought-tolerant could fare better under future projected climate scenarios. In Arkansas, these habitats would include glades and barrens, dry upland forests, and open woodlands/savannas. These conditions could also favor more wildfires on the landscape, thus potentially expanding these communities and improving habitat conditions for associated SGCN species.

Mesic forests would be more at risk to compositional changes due to drier conditions. Some of the species associated with these forests, such as sugar maple, would be expected to decrease (Brandt and others 2014). The dominance in these communities would shift to more tolerant species, such as sweetgum, white oak, and red maple. Forests in general could experience a decrease in basal area and canopy cover if trees are stressed by higher temperatures or rates of pest outbreaks increase.

Bottomland systems could be negatively impacted by the reduction of water coverage and altered hydrology. Forest cover in this system would be expected to increase with extended periods of dry weather and reduced water coverage. Seasonal/herbaceous wetlands and ephemeral ponds would especially be at risk for contraction and reduced habitat quality. In agricultural areas, such as the Mississippi Alluvial Plain, flood events could introduce herbicide and pesticide run-off into wetlands. Flood events would also increase sedimentation in wetlands and streams.

With overall warmer temperatures, conditions would be favorable for more non-native plant species from sub-tropical regions to invade communities. This would be especially true in areas where native species decline. Invasive non-native species would be an increased threat to all terrestrial habitats.

Aquatic Habitats

Aquatic systems could see substantial impacts from a changing climate. A reduction in available water, either due to decreased precipitation or increased evapotranspiration, would result in reduced stream flows and altered hydrology. Warmer air temperatures would result in increased water temperatures and reduced dissolved oxygen (Meyer and others 1999). Flood events would result in increased sedimentation and turbidity, as well as increased nutrient loading and agricultural run-off.

Potential Impacts to Species

There are 377 species listed as species of greatest conservation need in Arkansas. Because these species are already stressed by existing threats and because these threats will be further exacerbated by changes in climate, these species are more vulnerable to climate change impacts than other species.

Several factors determine how well a species will fare in light of a changing climate or, in other words, a species' degree of vulnerability to climate change. Vulnerability consists of three primary factors; exposure, sensitivity, and adaptive capacity (Stein and others 2014). Exposure is a measure of the character, magnitude, and rate of climatic changes a species may experience (i.e, direct climatic variables such as air temperatures, precipitation, water temperatures, etc.). Sensitivity is the degree to which a species is likely to be affected by climatic change and is related to life-history traits of the species (phenology, physiological factors, etc.). Adaptive capacity refers to the ability of a species to cope with climate change impacts. These 3 factors are utilized in vulnerability assessments that can rate the degree to which a species or system will be impacted (Glick and others 2011). We have not completed formal vulnerability assessments for species of greatest conservation need in Arkansas, though it is our intent to do so in the future as more data and appropriate resources become available. Completing vulnerability assessments would allow us to prioritize conservation actions and adaptation strategies to benefit the most at-risk species.

Below, we provide generalizations on how each species group may be impacted by the predicted changes in climate and factors that would influence response.

Mammals

In general, due to their high ability to disperse and generalized habitat and diet requirements, mammals would have a higher adaptive capacity to respond to altered climate and shifts in suitable habitat. However, bat species would be at risk for a number of reasons. Increases in air temperature could cause warming of roosts beyond what is tolerable for some species, causing them to abandon previously suitable roosts. Data for Brazilian free-tailed bats show that bats emerge earlier from hibernation during drought years, increasing competition for resources and the risk of predation (Frick and others 2012). Bat species that forage for insects over water would be negatively impacted by decreased prey availability and water coverage during drought events.

Birds

Birds have high dispersal ability, allowing them to shift their ranges to more suitable habitats and climatic conditions.

Many species of birds rely on insect availability for prey and migrant species may time their arrival to breeding grounds to occur with insect emergence. Increases in drought may decrease availability of insect prey and could potentially decrease reproductive success of birds. Nest success in Missouri has been show to decline under higher temperatures (Cox et al. 2013a) likely due to increased predator activity (Cox et al. 2013b). Degraded conditions on wintering grounds in the tropics (due to habitats becoming drier) may reduce the health of neotropical migrants as they migrate north to breeding grounds. This could result in decreased reproductive success and increased predation risk. Species that rely on wetlands (marshbirds and migratory waterfowl) and mud flats (shorebirds) would be negatively impacted by a reduction in available habitat due to increased drought events. Species that use open woodlands and glades would be expected to fare better, given that these habitats may expand in projected drier conditions.

Reptiles

Reptiles that require aquatic, wetland, or mesic habitats would be most impacted by predicted changes in climate. Available habitat in these systems would be degraded or reduced with increasing drought events. In their favor, reptiles have a moderate capability to disperse to more suitable habitats. Increases in habitat fragmentation and barriers to movements (i.e., roads) would reduce the adaptive capacity of this group.

Amphibians

Semi-aquatic and terrestrial amphibians typically prefer cool, moist microhabitats. With increases in temperatures and a decrease in available moisture, these microhabitats could be degraded or lost. In addition, many amphibians rely on ephemeral wetlands for breeding which may have shorter hydro-periods or lost altogether during this critical life history stage due to warmer temperatures and increased drought.

Amphibians have a limited ability to disperse long distances, which would reduce their adaptive capacity. Aquatic amphibians, such as the Ozark Hellbender and other stream salamanders, could be negatively impacted by increased stream temperatures, turbidity, and sedimentation.

Fishes

Warming stream temperatures will negatively impact fish by lowering dissolved oxygen levels and disrupting spawning timing. Increased siltation and agricultural run-off due to flood events will decrease suitability of habitat for many species. Fish species that rely on shallow pools and small streams would be most impacted by altered flows and drier conditions. Fish have dispersal capability, but only in systems without man-made barriers (i.e., dams).

Crayfish

Both aquatic and terrestrial species of crayfish would be negatively impacted by warmer, drier conditions. Aquatic species would be impacted by warmer stream temperatures, increased turbidity due to flood events, and a potential increase in the abundance of non-native crayfish species. Terrestrial, burrowing crayfish prefer cool, moist habitats. Drought events and higher temperatures would relocate the water table, altering available habitat.

Mussels

Increased sedimentation and turbidity in streams due to flood events would negatively impact many mussel species. Altered stream flows could also negatively impact species that require fast flowing streams. Because mussels are dependent on fish hosts for reproduction, any negative impacts to host fish become negative impacts to the mussel species.

Insects and Invertebrates

Insects and invertebrates that rely on aquatic systems for all or a portion of their life cycle would be impacted by warmer temperatures and drier conditions. Species with specialized habitat requirements and/or host plants could also be negatively impacted if populations of the obligate host plant are reduced. Most insects have the ability to disperse and some may migrate northward as climatic conditions shift (Parmesan and others 1999).

Adaptation Strategy

Because climate change has the potential to irrevocably alter species and habitat compositions across the landscape, it is imperative that natural resource managers strategize on the best approaches for adaptation (Mawdsley and others 2009). Incorporating climate change considerations into natural resource and wildlife management plans is an important first step. In Arkansas, our overarching goal will be to implement the wildlife action plan, which will increase adaptive capacity and affords our best chance of reducing threats to species and ensuring healthy, stable populations of SGCN that will be more resilient in the face of climate change. The goals outlined below are developed in line from those recommended in the National Fish, Wildlife, and Plants Climate Adaptation Strategy (National Fish, Wildlife, and Plants Climate Adaptation Partnership 2012).

Goal 1: Restore and maintain habitats to support healthy species populations and ecosystem functions. Loss and degradation of habitat is one of the most predominant threats for species of greatest conservation need. Restoring fully functioning habitats not only alleviates the threat to SGCN, but also provides alternative areas for species to shift their ranges onto if needed and available.

- Objective 1: Restore habitats to desired condition. It may be possible to ameliorate the effects of climate change through direct management activities. For instance, restoring a natural fire regime to grasslands and open woodlands will reduce fuel loads and lessen the potential for catastrophic wildfires.
- Objective 2: Provide connectivity between habitats. Providing stepping-stones between tracts of habitats will improve the ability of species to migrate to more suitable conditions. Providing additional refugia for species will improve species' chances for survival.

Goal 2: Protect key areas or habitats. Increasing the amount of lands protected from urbanization, fragmentation, and degradation increases the opportunity to provide restored habitats for species. In addition, some species have very specific, narrow habitat requirements. Protecting particular habitats where these species occur will decrease the risk of extinction for these species.

- Objective 1: Create a network of protected lands that meets the needs for a diversity of wildlife. The Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative is currently working to develop comprehensive conservation strategies for the each of the sub-geographies within the region. This would include the Arkansas ecoregions Ozark Highlands, Mississippi Alluvial Plain, and West Gulf Coastal Plain. The product of this effort will be the identification of conservation opportunity areas that provide a foundation for strategic planning. Climate change impacts, as well as other threats (e.g. fragmentation due to expanding urbanization), are included in this planning process.
- Objective 2: Identify and protect critical habitats for specialist species and/or narrow endemics. Identifying high-priority caves and their recharge areas has been a priority conservation action under the wildlife action plan. Protecting important hibernacula will

help ensure the long-term sustainability of cave bat populations. Also, identifying and protecting habitats that are home to endemics, such as salamanders and darters, should remain a high priority.

Goal 3: Increase adaptive management capacity. Climate change information and tools are developing rapidly. In order to be proactive in our management, it is crucial to remain up-to-date on information and tools available to us.

- Objective 1: Continue to coordinate with the Landscape Conservation Cooperatives, Climate Science Centers, and other entities regarding the latest science and tools for use in conservation planning and wildlife management.
- Objective 2: Incorporate climate change considerations into species and habitat management plans, where feasible.

Goal 4: Monitor the response of species and habitats to climate change. Monitoring programs provide information that natural resource managers can use to adjust their activities. Monitoring becomes particularly important when changes are anticipated to occur at a fast rate, such as with climate change.

- Objective 1: Continue to implement monitoring priorities as outlined in the Wildlife Action Plan. This includes breeding bird surveys, Christmas bird count surveys, pollinator surveys, etc. These long-term data are important for determining population trends and will be especially important for detecting any changes in species phenology or distribution as a result of climate change.
- Objective 2: Participate in other regional and national monitoring programs as they are developed.

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