Birds are integral components of ecosystems and account for billions of dollars in tangible benefits to humans. As such, recent continental declines of bird species have ecological and economic consequences, providing the impetus for my dissertation research. I identified knowledge gaps and proposed novel questions about how birds in the Appalachian Mountains are influenced by changing environmental conditions due to climate change and forest management. The Appalachian Mountains encompass an important biogeographical region with high conservation value due to its myriad habitats and corresponding bird species diversity. Thus, there is a critical need to evaluate the effects of shifting climate factors and land management decisions on long-term trends in bird populations in this region. I designed my dissertation research to fulfill that need, developing 4 chapters that investigate the effects of temperature, precipitation, land cover, and management actions on Appalachian forest bird communities.

The first 2 chapters of my dissertation emphasize the role of climate in the Appalachian Mountains. In Chapter 1, I determined the potential effects of both climate and land cover change on forest songbirds of the Appalachian Mountains by conducting a comprehensive review of published literature and presenting a novel case study. The literature review focused on synthesizing documented and predicted changes in bird species distributions, population dynamics, and communities in response to changes in both climate and land cover across the Appalachian Mountains. I concluded by noting the dearth of studies from the Appalachian Mountains that track long-term avian responses, particularly population dynamics, to changing climate and land cover. For my case study, I used 20 years of North American Breeding Bird Survey data from 322 survey routes within the Appalachian Mountains Bird Conservation Region to model the regionwide abundance and distributions of 14 songbird species, disentangle the influences of climate versus land cover change, and predict the consequences of future shifts in climate and land cover patterns. I found that both climate and land cover variables were important in shaping forest songbird distributions. However, the proportions of land cover types tended to be more influential and had higher effect sizes than temperature or precipitation amount. When predicting future distributions of the 14 focal forest songbird species within the Appalachian Mountains, the future climate and land cover combination scenarios had varying but limited impacts on projected relative abundance, regional occupancy, and shifts in the distribution of relative abundance, with the strongest consistent effects on cold-associated species and the 2 warmest scenarios resulting in the greatest differences between contemporary and future projections. Overall, the net projected impact on breeding forest songbirds within the Appalachian Mountains from climate change was modest at a broad spatiotemporal scale, but there may be cause for conservation concern for cold-associated species if greenhouse gas emissions remain high. Furthermore, based on the importance and effect sizes of land cover variables in this case study, land use changes that result in reduced forest cover and increased urban cover may pose a more immediate threat than climate change to birds in this region.

The second chapter of my dissertation takes a finer-scale approach compared to Chapter 1 and investigates whether the influence of climate change on forest songbirds in the Appalachian Mountains is mediated by latitude and elevation. In Chapter 2, I quantified differences in how forest songbird communities are affected by climate factors and additionally explored concurrent temporal trends across latitudinal and elevational gradients within the Appalachian Mountains. My specific objectives were to apply interactions with both latitude and elevation in quantifying how temperature, precipitation, and other temporal factors influence climate-related guild richness and the abundance of specific focal species during the breeding season. I used nearly 30 years of bird survey data from 1,733 sites at various elevations in National Forests located within the Northern, Central, and Southern Appalachians to model responses in guild richness and focal species abundance to climate factors and long-term temporal trends. I found that guild-specific relationships varied among latitudinal regions and along elevational gradients within the Appalachian Mountains. The results of this study are valuable for understanding historical effects of changing climate factors and improving predictions of future climate change impacts on forest songbirds in the Appalachian Mountains by verifying and delineating the dynamic nature of the relationships with temperature and precipitation across latitudinal and elevational gradients. They will also help to inform forest songbird conservation efforts in the Appalachian Mountains because they quantify the regional effects of temperature and precipitation on climate-related guilds and forest songbird species and identify specific latitudes and elevations at which they are at the highest risk from climate change and other temporal factors. Based on my models, climate mitigation strategies for forest songbirds in the Appalachian Mountains are most needed for cold-associated species and for low elevations in the Southern Appalachians.

My final 2 chapters focus on the role of land management decisions within the Central Appalachians region. In Chapter 3, I used 17 years of historical bird survey data to fill a knowledge gap about long-term bird responses to landscape-scale forest management by investigating how avian diversity, abundance, and population dynamics changed over time in 2 Central Appalachian forested landscapes with varying levels of timber harvest intensity. My specific objectives were to examine the influence and effect of interactions between time and landscape-level timber harvest intensity on breeding season songbird guild richness, focal species abundance, and focal species nest success. I found that guild richness and focal species abundance tended to be consistently higher in the actively harvested landscape, and trends in guild richness and species abundance over time were consistently positive in the actively harvested landscape and negative in the minimally harvested landscape. In particular, early-successional / edge-associated species and forest-gap species were found in higher numbers and exhibited positive temporal trends in the actively harvested landscape. However, a holistic assessment that included trends in reproductive success highlighted long-term declines in nest success for a forest-interior species of regional conservation concern within the actively harvested landscape but not the minimally harvested landscape. Thus, there are important trade-offs to consider when using landscape-scale forest management to promote songbird communities and populations in forested landscapes.

The fourth chapter of my dissertation addresses specific management efforts to promote target game birds and a diversity of breeding and post-breeding songbirds in heavily forested landscapes. In Chapter 4, I collected extensive data from 335 wildlife openings within the Monongahela National Forest, and then quantified how a suite of site-level and landscape-level wildlife opening attributes relate to multi-species occupancy of 3 game birds (wild turkey, ruffed grouse, and American woodcock) during the game bird courtship season and songbird guild richness during the breeding and post-breeding seasons. I found that game bird species occupancy in wildlife openings may be best explained by management actions and local habitat attributes. My findings further indicated that it is feasible to manage wildlife openings for the mutual benefit of different species groups across seasons. I presented a set of management recommendations to maximize occurrence of wild turkey, ruffed grouse, and American woodcock in concurrence with breeding and post-breeding songbird occurrence within wildlife openings, with considerations for minimizing negative impacts to breeding songbirds in adjacent forests. These actions be applied by private landowners, non-governmental organizations, and government agencies to simultaneously meet management goals and promote diverse forest ecosystems.

Combining all 4 chapters, my dissertation research generates critical knowledge needed to manage and conserve important natural resources that are ecologically and economically valuable. My first 2 research studies advance understanding of climate change effects and underscore the significance of the Appalachian Mountains to regional bird communities, especially cold-associated bird species, with important implications for mitigating large-scale threats to biodiversity. The final 2 research studies provide specific management considerations and recommendations for Central Appalachian forests that will holistically benefit and sustain many forest bird species, including target game birds and species of regional conservation concern.