NE CASC
Northeast Climate Adaptation Science Center

Climate impacts on land-use and land-cover change

Understanding the interactive and cumulative effects of climate and land-use changes are a priority for the NE CASC as it will affect the distribution, composition, condition and vulnerability of regional biomes including forests, grasslands, shrublands, prairies, alpine tundra, and human managed systems (e.g. agricultural lands and forestry) (Grimm et al., 2013). Impacts from agriculture, urbanization, energy and infrastructure development have already and will continue to directly modify land-cover through habitat loss, degradation, and fragmentation (Sala et al., 2000; Staud et al., 2013) with additional indirect impacts that radiate to freshwater systems (Theme 3), and ultimately, coastal and nearshore environments (Theme 4). To date, human activities have been the primary source of land-use and land- cover changes; however, climate change is expected to exacerbate and accelerate impacts on terrestrial, hydrological and climatic regimes, as well as increase the vulnerability of species (Theme 5) and cultural (Theme 6) resources (Staudinger et al., 2012; Staud et al., 2013). Adaptation and mitigation strategies that account for climate change interactions with multiple anthropogenic stressors will be critical to minimize further loss of terrestrial habitats that support important ecosystem services such as primary production, nitrogen and carbon cycling (Nelson et al., 2013a).

Predicted increases in precipitation and temperature extremes will exacerbate the impacts of many landscape-scale stressors on natural and cultural resources. For example, increasingly warmer and shorter winters due to climate change in the Northeast are conducive to the proliferation of biological disturbances. Invasive species, diseases, and insects such as recent outbreaks of hemlock woolly adelgid, Asian longhorn beetle, and emerald ash borer have already caused widespread damage and loss of forests throughout the region (Paradis et al., 2008). Such large-scale disturbances across the forest-rich landscapes of the NE CASC region can have important negative feedbacks on the carbon and mitigation benefits currently provided by this region (cf. Kurz et al. 2008). In addition, systems that are already stressed from biological disturbances, exploitation, or pollution are likely to be more sensitive to the impacts of climate change, potentially amplifying the effects of these multiple stressors (Staud et al., 2013).

Management agencies in the NE CASC region have prioritized the development of robust land-use change projections and models to design landscapes that are sustainable in the face of climate and landscape changes. This is in part due to shifts in temporal and spatial land-uses driven by urbanization and human development as well as natural and human responses to climate change (e.g., shifts in seasonal and latitudinal planting zones). Areas that are relatively vulnerable to climate change or have high ecological value have also been identified as being particularly important research targets. Heterogeneous land-cover caused by development and agriculture, numerous privately owned parcels of private land, patchwork jurisdictions, and relatively limited federal and public lands in this region make these issues even more complicated and require participation, cooperation, and successful coordination of diverse stakeholders.

Simple models based on the climate associated with current species distributions (e.g., climate envelope models) have been helpful in giving initial or first-order estimates of the effects of climate change. However, this coarse-filter approach can lead to either over or underestimates of the rate and extent of landscape change, particularly in strongly human-influenced landscapes or in those with a high degree of fine-scale variability in climate conditions (e.g., mountainous or near-coastal regions). A key element of this science theme is the development of models which incorporate the response of the vegetation communities that constitute diverse natural communities (e.g., forests, shrublands, grasslands), human responses (urban and residential development, agricultural, forestry, wildlife management practices, mining impacts, and bioenergy development), and changes in natural disturbance regimes (fire, wind, flood, drought, and insects and disease). Studies of historical impacts in the Northeast can help inform these models, but understanding the changes in land-use and land-cover over recent time and how they impacted other systems (such as sediment flux, nutrient transfer, wildlife distribution, etc.) are also very important to linking together landscape-scale impacts of climate and land-use.

Progress along these lines requires assessing a range of approaches including both habitat capability and ecological integrity models that are under development at several NE CASC partner institutions (UMO, UMass, UMN, UWI). The habitat capability models are focused on a suite of surrogate species that link fish and wildlife population dynamics (survival, reproduction, dispersal) with habitat changes. The ecological integrity models focus on a suite of ecological systems to be used as a coarse filter for evaluating landscape and climate change scenarios. Models with greater spatial resolution that address build-out or grow-out can be used to simulate changes, particularly in human-dominated landscapes, associated with regulatory practices and socio-economic drivers, such as human population growth or changes in agricultural or forestry practices. Acknowledging the uncertainty inherent in all of these modeling efforts, the goal of the NE CASC is to provide managers with a well-supported set of alternative scenarios largely through decision analysis frameworks (Brown et al., 2011; Rowland et al., In press).

Because urban areas are generally warmer than surrounding (less developed) lands, they may serve as models to examine and evaluate the potential impacts of climate change. In some cases, current within-city temperature differences can be as large as projected warming at multi-decadal to centennial scales (Horton et al., 2011). Consequently, microclimates within existing and expanding urban areas, created by a phenomenon known as the heat island effect (Oke, 1987), can improve our understanding of how, for example, urban forests respond to extreme temperatures. In addition, urban watersheds may be used to evaluate the combined impacts of human stressors, such as pollution, and extreme precipitation and flooding events. The responses of different types of lands within the urban areas of the Northeast CASC region will provide important comparisons of impacts on biodiversity and ecosystem functioning in surrounding rural areas (Imhoff et al., 2010).

The NE CASC will work closely with federal agencies and other partners in the region (e.g., Eastern Geology and Paleoclimate Science Center, USFS Northern Institute of Applied Climate Science, and the newly established USDA Regional Climate Hubs) to complete the following:

Recommendations

- Work with partners (e.g., USDA Climate Hubs) to characterize and model regional impacts of land management practices (i.e., agriculture, urban, and energy development) and climate changes on ecological integrity.
- Assess the current and future capacity of landscapes to support ecological functions and sustainable fish, wildlife, forestry and agricultural resources.
- Work with the USFS and other partners to improve the understanding of forest management practices and strategies that maximize resilience to changes in climate and natural disturbance regimes.
- Partner with existing efforts in the region (e.g., Northern Institute of Applied Climate Science) to develop decision support tools that assist Federal, State, Tribal, NGO, and private landowners design and manage sustainable landscapes for increased resilience, connectivity, and conservation under climate and landscape changes.

- Use decision analysis tools to identify climate and landscape-scale impacts, risks, and uncertainties and provide guidance on key decisions in the region.