Aspen conservation

Drivers of aspen growth, recruitment, and mortality in the Western United States.

Topic: Aspen conservation

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Forests cover 30% of the globe's terrestrial surface area and play critical roles in climate and biogeochemical cycles. However, there is growing concern that many tree species are in decline due to large-scale tree mortality, contracting stand cover, and reduced recruitment. Climate has been recognized as a driving factor in many mortality events around the world, but our understanding of how climate change will affect forests is still limited. Quaking aspen (Populus tremuloides) is a foundational species which harbors high levels of biodiversity and provides significant ecosystem services, yet aspen have experienced recent, large-scale dieoffs in the western U.S. Given that aspen's range encompasses large environmental gradients, they offer an excellent opportunity to investigate the impacts of climate and climate change on forest ecosystems. We investigated patterns and drivers of aspen growth, recruitment, and mortality using long-term forest inventory data collected from 184 plots located across California, Nevada, Idaho, Wyoming, and Utah. The plot network was established from 2006-2009 and resampled once in 2019. We found extremely high levels of mortality overall, with 49% of all adult aspen trees in the network dying during the 10-13 year study period. However, we also documented a high degree of variability in aspen performance. We analyzed the effect of climate, topography, and stand structure on aspen growth, recruitment, and mortality. We found precipitation and topographic position index (20km radius neighborhood) to be negatively associated with mortality. Stand live basal area was negatively associated with both growth rate and mortality, while spring and summer temperature was positively associated with both growth rate and mortality. This large spatial scale study enhances our knowledge of the widespread patterns of aspen performance, and offers insight into the drivers of aspen performance across the environmentally heterogenous landscapes in which it occurs.

Environmental impacts on mortality and recruitment depend on genotype and ploidy level in quaking aspen

Topic: Aspen conservation

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Species response to climate change depends on environment, genetics, and interactions among these factors across individuals. Intraspecific ploidy level variation is a common type of genetic variation in many species, and drives variation in ecophysiology. However, the importance of intraspecific ploidy level variation in determining demography across environments is still unknown. Here we study the tree species quaking aspen (Populus tremuloides), which occurs in diploid and triploid forms within many populations. Quaking aspen is experiencing strong mortality across its range ('sudden aspen decline') which could potentially be linked to ploidy-level dependent drought tolerance. Here we show that interactions between ploidy level and environment drive survival and recruitment rates across 503 demography plots in Colorado. Triploids were more vulnerable to mortality relative to diploids and had reduced recruitment on more drought-prone and disturbed sites relative to diploids. Furthermore, there was substantial genotype-dependent variation in demographic rates. These results provide a mechanism underlying the strong spatial patchiness of decline in this keystone species. Future assessment of 'winners' and 'losers' under climate change and forecasting drought-induced range shifts of quaking aspen will thus require knowledge of how genetic and environmental mosaics interact to determine species' demography.

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SYMPOSIUM: The Quaking Aspen Challenge: Applied Conservation in Keystone Communities

A decade of monitoring aspen restoration in the Lake Tahoe Basin: synthesis of research applicable to management

Topic: Aspen conservation

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Aspen is a keystone species important to wildlife, water quality, biodiversity, recreation, and aesthetics in the west. In the central Sierra Nevada, the Lake Tahoe Basin is home to scattered small aspen groves that are surrounded, outsized, and being outcompeted by conifer forests. In the absence of natural disturbances such as frequent mixed-severity wildfire, these aspen groves have been undergoing succession to conifer for decades and were being lost. More recently, many groves have been restored by various land management agencies. In collaboration with these agencies, we regularly monitor outcomes of their operational-scale restoration activities in aspen groves. We also monitor untreated groves for comparison. These monitoring collaborations have generated a series of applied research publications in scientific journals. Here we synthesize the key findings of these studies that apply directly to the practice of aspen forest ecosystem restoration. The focus is on restoration thinning treatment responses of aspen regeneration, conifer regeneration (unwanted), and herbaceous vegetation, plus the forecasted future growth of trees and longevity of restoration treatments, and the most recent findings on aspen ecosystem responses to piling and burning of conifer wood from trees cut as part of the aspen restoration activities. The monitoring is ongoing, tracking trends and generating ever more data and information supporting adaptive management.

Avian-Aspen Relationships in the Sierra Nevada

Topic: Aspen conservation

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The importance of quaking aspen to birds and other wildlife in western North America has long been appreciated by biologists. Many studies from this region have demonstrated that aspen habitats typically support much greater diversity, richness, and abundance of birds than adjacent habitats, and several bird species have shown a strong affinity with aspen. This talk will provide an overview of bird-aspen relationships in the Sierra Nevada and highlight research investigating habitat correlates of bird species richness and abundance, aspen as a barrier to nest predators, habitat correlates of nest success, avian nest-site selection within aspen, short-term impacts of mechanical conifer thinning in aspen, and impacts of recent White Satin Moth invasion to the region.

Long-Term Dynamics of Aspen Stands in the Lake Tahoe Basin: a 34-year Analysis of Conifer Encroachment using Landsat

Topic: Aspen conservation

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Global climate change, land use legacies, and insect defoliators can have severe implications on forest composition, structure, and regeneration with long-lasting effects on ecosystem services. In the Lake Tahoe Basin (LTB), quaking aspen stands support high levels of biodiversity, provide recreational opportunities, and help maintain water quality. Despite the benefits that aspen provide, aspen stands in the Lake Tahoe Basin have declined in cover due to insect defoliators, fire suppression and conifer encroachment. Recently, managers in the LTB have adopted practices, including fuel reduction and conifer thinning, intended to combat the negative effects of fire suppression and conifer encroachment on aspen regeneration. However, little is known about how aspen canopy cover has changed in the past several decades across the LTB and what areas are most likely to achieve restoration success.

Using the Landsat satellite archive, we performed spectral mixture analysis to identify trends (1984 – present) in the fractional cover of healthy aspen, defoliated aspen, and conifers and to map hotspots of defoliation and conifer encroachment within the LTB. To identify Landsat pixels containing aspen we developed the highest resolution and most accurate aspen map in the LTB to-date. This map was created using a combination of leaf-off and leaf-on imagery and LIDAR. To validate our conifer encroachment mapping we hand-digitized 6,186 conifer crown polygons across 138 aspen stands. To identify abiotic conditions most associated with defoliation and conifer encroachment we created predictive models using a wide variety of topographic, soil, climatic, and stand characteristics.

Our high-resolution aspen map identified 553 aspen stands that comprised 1.4% (931 hectares) of the total land area in the LTB. Within the subset of aspen stands where conifer cover was digitized, an average of 11.4% of the present aspen stand area was occupied by conifers. Although our trend analysis is ongoing our preliminary results suggest that there are distinct abiotic conditions that favor conifer encroachment that differ from stands subject to defoliation. Defoliation was most common in many of the largest stands in the basin whereas conifer encroachment tended to occur in smaller stands and along edges. Our 30-meter spatially-explicit maps of conifer encroachment rates and defoliation are being incorporated into a decision support system that enables land managers to identify areas with the greatest benefit-to-cost ratio for habitat restoration. Management criteria include distance to existing roads, slope, distance to riparian areas, stand size, stand connectivity, existing conifer cover and conifer encroachment rate.

Long-term patterns in aspen performance across North America during a period of unprecedented climate change

Topic: Aspen conservation

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Forests cover 30% of the Earth's terrestrial surface and have large influences on biogeochemical processes and provide a wide range of ecosystems services. However, throughout the world, an increasing number of tree species are reported to be declining in abundance due to large-scale tree mortality and/or reduced regeneration. Many factors have been implicated as drivers of tree decline, but stress caused by elevated temperatures and drought associated with anthropogenic climate change have emerged as important factors. Understanding the dynamics and spatial extent of tree decline is of great importance given the essential role that trees play in ecological systems.

Quaking aspen (Populus tremuloides) is ideally suited for studying the dynamics of tree decline: 1) it is the most widespread tree species in North America; 2) it inhabits a wide range of environments that are exceptionally variable in topography and climate; and 3) previous research has shown that its performance can be quite variable, exhibiting declines in some parts of its range and no changes in others. Using long-term data from a continent-wide plot network, we have evaluated mortality, growth and recruitment rates of aspen across its range to better understand the vulnerability of this species to global change.

Our data summarize long-term patterns in mortality, growth and recruitment rates of aspen in forest inventory networks established by state, provincial and federal agencies in Canada and the U.S. Mortality rates of adult aspen increased substantially over the past 20-35 years, with patterns persisting in stands of different ages, densities, and compositions. In contrast, recruitment rates of adults decreased through time, with patterns varying with forest composition and age structure. To a lesser extent, growth rates of aspen also decreased through time, although they varied less with composition and stand structure.

The demographic rates of aspen varied greatly among the five biomes that the tree inhabits in North America. For example, recruitment and growth rates were substantially lower in coniferous and boreal forests compared to three other biome types. Within all biomes, we explore the importance of recent climatic anomalies and topographic heterogeneity in predicting demographic rates of aspen.

In summary, our analyses of the long-term dynamics of aspen across its entire geographic range indicate that aspen populations are experiencing region-specific shifts in background demographic rates, with changes most pronounced in regions most affected by recent climate change (i.e., arid and high-latitude environments).

Quaking Aspen Science & Management in Dynamic Times

Topic: Aspen conservation

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Quaking aspen (Populus tremuloides) science is experiencing a renaissance, of sorts, in terms of multiple advances in related disciplines. Novel findings in genetics, biodiversity and bioindicators monitoring, climate modeling, seedling episodes, chemical defense, herbivore impacts and movement, and fire ecology are all changing the way we think about aspen systems. However, management practices lag behind in their implementation of actions in concert with these discoveries. This presentation will frame recent contributions to aspen ecology that will be detailed in follow-up talks in this Aspen Conservation Special Symposium, as well as describe sound management practices to complement contemporary aspen sciences. Such actions, grounded firmly in adaptive monitoring and ecological restoration, are aimed at preserving ecosystem resilience as we navigate uncertain climate futures. Another aspect of this talk will examine the role land ownership and status (reserved vs. unreserved) plays in often diverging ecologies of aspen forests. Both land and wildlife management practices may promulgate resilience or exacerbate decline. A key tenet of modern land stewardship is emulation of natural processes in practical application. This approach is thought to increase the odds of success or 'â€¦to keep every cog and wheel [as the] first precaution of intelligent tinkering.' as the sage words of Aldo Leopold suggest. Thus, this presentation will provide an overview of advances in aspen ecology, as well as give a functional ecology playbook for implementing management strategies that are knowledgeable and flexible. The expectation is that the work presented here will be of interest to applied scientists and field practitioners interested in aspen conservation.

The Quaking Aspen Challenge: Applied Conservation in Keystone Communities

Topic: Aspen conservation

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Quaking aspen (Populus tremuloides) occurs across the continent, but displays different functional qualities under widely varying conditions. For instance, Great Basin and Sierra Nevada aspen often have divergent aspen 'ecologies.' Not only do diverse ecologies affect aspen, but a history of human-induced alterations present challenges for the sustainable management of these keystone systems. In order to bridge science-stewardship divides, this session will explore practical, ecologically-based, actions to restore resilience in systems threatened by climate change, herbivory, land conversion, past management, residential development, and other practices. In keeping with NAC 2020's theme, we will recruit presenters with varied geographic and disciplinary foci, meshing science and stewardship with the overall objective of enhancing aspen landscapes. In this region, aspen span a nearly 4,000 ft. (1,020 m) elevation range; thus, we will aim to address aspen functional types co-located with both sagebrush and subalpine forests. Specifically, we will address wildfire, herbivory, climate warming, development pressures, cross-boundary management, and regional monitoring of aspen in the West. A driving paradigm in forest ecology is emulation of natural processes in practical applications. This session will take that approach for aspen ecosystems to the next level: through presentations and a summary discussion we aim to match current ecological understanding with practical application. Our 'gradient' motif will ensure a diversity of western American aspen conditions and practices. Through open and thoughtful information exchange, participants will come away with a trove of new management tools and insights, technical resources, and professional connections for addressing aspen resource issues at local, regional, and continental scales.

The role of climate and fire in shaping aspen forests of the Great Basin: altered dynamics and management challenges

Topic: Aspen conservation

Douglas Shinneman
U.S. Geological Survey

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Quaking aspen (Populus tremuloides) forests are considered to be in decline across large portions of the western U.S. due to the effects of drought, fire-exclusion, excessive herbivory, insects, and pathogens. However, aspen forests are also considered persistent or even locally expanding in other areas. In the northern Great Basin and surrounding regions, where arid sagebrush-steppe landscapes typically dominate, aspen are found in isolated mountain ranges and often form the only forest ecosystem with substantial areal extent. Loss of aspen forest area in the Great Basin could result in substantial habitat loss for myriad species that disproportionately utilize aspen ecosystems relative to surrounding habitat. Here we discuss some of the key issues affecting aspen in the Great Basin, including interactions between changing climate, altered fire regimes, and herbivory. As the western U.S. becomes increasingly vulnerable to drought, the distribution of aspen forests is likely to contract. This may be especially true in the Great Basin, a region with strongly winter-dominated precipitation regimes and extremely dry summers, in which forests are likely to be particularly affected by declining snowpack. Conversely, because aspen is a fire-adapted species that vegetatively reproduces after disturbance, aspen forests could simultaneously benefit from increasing wildfire activity in the western U.S. We will examine recent research that suggests the relative importance of fire in aspen ecosystems of the Great Basin, including evidence that many aspen forests in the region are stable and don't depend on fire for regeneration and persistence. We will also highlight the importance of adequate precipitation, including during winter, for aspen regeneration in both unburned and recently burned stands in the region. We'll use modeling studies and recent field-based research to discuss how these relationships are likely tenuous in the region, especially given expected and observed changes in climate over time and space. Lastly, we will discuss how interactions among various stressors could occur in novel ways under global change dynamics, making it challenging for land managers to identify, prioritize, and manage at-risk aspen forest habitats. In particular, we will consider how additional factors, such as chronic ungulate herbivory and nonnative species, could interact with changes in climate and fire regimes to contribute to declining aspen populations or shifts in forest-shrubland ecotones.

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