My 2020 ESA Annual Meeting (August 3 - 6) Schedule

Abstract

The dispersal dynamics of ecosystem engineers

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Ecosystem engineers are organisms characterized by significantly modifying their habitat. Some examples of these ecosystem engineers are invasive species, such as *Spartina alterniflora* cordgrass or the zebra mussel *Dreissena polymorpha*. In some cases, the effect of modifying the environment can be non-local, affecting other regions farther away from the region populated by the ecosystem engineer.

In this context, we are interested in understanding how these populations can disperse through their environment. We want to answer questions such as: Which conditions promote the invasibility of ecosystem engineers from one patch to another? and, is there any possible control strategy that can be applied to these populations to avoid invasion?

To do this we have developed an extension of the ecosystem engineer population model of Cuddington et al (2009). Asymptotic analysis is then performed on this model to understand the relation between migration and engineering, both local and regional.

Results/Conclusions

In this poster we present the main results of this analysis, where we focus on conditions for spread of an ecosystem engineer. In Cuddington et al (2009) it was identified that locally, this population behaves similar to an Allee effect with a time lag. Here we find that this behavior is extended to the regional level. Spread between patches is not possible if both dispersal and the engineering effect are low enough. If either process is strong enough, then spread is possible. These results suggest that control of spread of invasive engineers could focus on either reducing dispersal or counteracting the engineering effect.

Abstract

Comparing management strategies for conserving climate-threatened species with a stochastic metacommunity model

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

With habitat fragmentation and projected rates of climate change, some species could face extinction if they cannot reach high-quality habitats in climates within their physiological limits in the future. One strategy to prevent the extinction of these species is assisted migration, the purposeful relocation of species beyond their historical ranges. Because it is usually presented as a single-species approach, assisted migration is often contrasted to several alternatives management strategies that could conserve entire communities of climate-shifting species. In particular, increasing connectivity, restoring low-quality habitats, and preserving existing high-quality habitats might also benefit climate-threatened species, provided they can reproduce and disperse quickly enough to track climate change. To evaluate the effectiveness of each of these alternatives in a variety of communities and environments, we modeled the climate-tracking of randomized competitive metacommunities

with several alternative management interventions. In each landscape, we represented habitat fragmentation by varying the carrying capacity over space, including the size of low-quality sinks and high-quality sources. To compare management strategies in different environments, we also randomized the local climate heterogeneity and the magnitude of environmental stochasticity.

Results/Conclusions

On average, corridor establishment and assisted migration were the most effective alternatives at retaining the alpha and gamma diversity in the metacommunities experiencing climate change. Though assisted migration typically led to the greatest reduction of extinction likelihood for short-dispersing species (and the only strategy to do so in unfragmented landscapes), it could require extensive management effort in moving several species multiple times. In general, the effectiveness of each management strategy was sensitive to small increases in management effort with diminishing returns with higher effort. Moreover, all strategies effectively conserved species in competitive environments where poleward competitors could otherwise block equatorward species from tracking climate change. Overall, assisted migration could be an effective multi-species approach as long as there are only few dispersal-limited species in a competitive community and low risk from factors that we did not model (such as pathogen transport). Given similar biodiversity protection performance between assisted migration and traditional methods for increasing connectivity, the optimal approach will then depend on the capacity to implement these strategies and tolerance for additional risks they might incur.

Abstract

Using stable isotope analysis and foliar growth measurements to understand physiological responses to drought in whitebark pine

Jennifer Cribbs, Environmental Policy and Management, University of California at Davis, Davis, CA, Jonathan Nesmith, Sierra Nevada Network Inventory and Monitoring Program, National Park Service, Three Rivers, CA, Phil van Mantgem, Western Ecological Research Center, USGS, Arcata, CA and Joan Dudney, Department of Plant Sciences, University of California, Davis, Davis, CA

2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Whitebark pine is a keystone species in high elevation systems in the Sierra Nevada. Precipitous declines in this species due to a combination of threats have led to proposals to list whitebark pine as an endangered species. Improved understanding of the broad impacts of climate on whitebark forests may be valuable in creating adaptive management plans for this species that take projected climate change into account. In this study, we describe the impacts of the recent drought in California on whitebark pine physiology and growth. We collected needle samples from over 1000 trees in 24 plots that scanned diverse climatic conditions. Needle samples were dried, measured, and pulverized then sent to the Analytical Lab and Stable Isotope Facility at UC Davis for analysis of $\delta^{13}C$ and $\delta^{15}N$. Key questions included, 1) how did the drought shift foliar growth (needle length) and foliar stable isotopes, δ13C and δ15N? 2) where did whitebark respond most positively and/or negatively to climate and drought? and 3) did whitebark experience drought stress?

Results/Conclusions

While the region as a whole experienced drought conditions, whitebark pine showed positive growth responses and increased photosynthetic capacity (decreased $\delta^{13}C$ ratios) during the drought. Only two plots contained trees that may have showed signs of drought stress, though the results were inconclusive. These trees occurred on the eastern side of the Sierra Nevada in one of the hottest, driest regions of California's whitebark pine range. Beyond these eastern Sierra plots, whitebark in the subalpine may be limited more by short growing season length and higher snowpack rather than drought. Plots in areas with high snowpack showed even greater increases in needle growth and photosynthetic capacity relative to low snowpack areas. Future work will continue to improve understanding of how whitebark pines respond to climate variables, providing a foundation for species management and restoration plans.

Abstract

Nonlinear climate change impacts on infectious tree disease

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Though climate change is predicted to cause major shifts in infectious disease risk, definitive evidence is often elusive due to data limitations and confounding factors. Thus, disease outbreaks are often interpreted as stochastic events, rather than a response to changing environmental conditions. Nonlinearities in climate change patterns can also complicate inference of mechanistic drivers. Nonlinear stochastic events, such as droughts, are predicted to increase in frequency and severity throughout various parts of the globe and negatively affect fungal pathogens. Here we take advantage of a unique long-term dataset (two survey periods spanning ~19 years; over 8,000 individual hosts) of the fungal tree disease, white pine blister rust (*Cronartium ribicola* Fisch., blister rust). We predicted that blister rust was nonlinearly related to climate. Due to this nonlinear relationship, we expected that climate change over the past nineteen years shifted blister rust nonlinearly, increasing infections in colder regions and decreasing infections in hotter, drier regions. We hypothesized that a mechanism driving the nonlinear range shift was an interaction between increased water stress and blister rust infections. Finally, we predicted that the combined direct and interacting effects of climate change on blister rust resulted in a range shift, not a range expansion.

Results/Conclusions

Using a novel, first differences panel modeling approach, we found evidence of nonlinear responses of disease spread to rising temperatures. This nonlinear effect increased infections in colder climates and may have decreased new infections in the hottest, driest conditions. We demonstrated that the interaction of disease and water stress in infected hosts contributed to nonlinear shifts in pathogen infections. Though many studies predict nonlinear climate effects on disease spread, we present some of the first empirical evidence of this relationship. Our results underscore the importance of quantifying nonlinearities in climate–disease interactions to improve predictions of disease outbreaks.

Abstract

The role of bark beetles as a contributing factor to tree mortality in an Eastern Sierra *Pinus jeffreyi* stand

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

During the 2011-2017 drought, bark beetles killed millions of trees across California burrowing through their bark and laying their eggs in the trees' cambium. Warming caused by climate change has helped these beetle populations survive through the winter and quickly reach maturity. This warming, coupled with drought, has created the perfect environment for these beetles to thrive, since they are most likely to attack drought-stressed trees. The red turpentine beetle (*Dendroctonus valens*) infests pines native to the Eastern Sierra. Typically, unlike other *Dendroctonus* species, red turpentine beetles do not kill their host trees which gives us a unique opportunity to use dendrochronology to study past outbreaks in a monospecific *Pinus jeffreyi* stand. At our study site, we investigated the spatial scale of the *Dendroctonus valens* infestation as well as the interacting causes of tree mortality, including fire intensity and tree size. We used tree survey data collected from Indiana Summit (37° 48′ 13.2″ N, 118° 54′ 16.2″ W) and O'Harrell Canyon (37° 45′ 54.2″ N, 118° 44′ 07.8″ W) in 2018, and a dendrochronological reconstruction of the two stands using 129 *Pinus jeffreyi* cores collected in 2018 and 2019 to analyze the effects causes of mortality and decreased growth rates in this stand.

Results/Conclusions

Evidence of red turpentine beetle was found in trees at both Indiana Summit and O'Harrell Canyon. The percentage of trees with beetles at each site was 4.03% (N=541) at Indiana Summit and 1.99% (N=251) at O'Harrell Canyon. At Indiana Summit 9.73% (N=185) of dead trees had evidence of beetle infestation, while none of dead trees (N=20) had evidence of beetle infestation at O'Harrell Canyon. We used a logistic regression to determine traits that predict tree mortality in this system. We found that smaller trees' DBH ($p = 2e\text{-}16$), larger scorch heights ($p = 7.24e\text{-}12$), and evidence of beetle infestation ($p = 0.00266$) were all significant predictors of tree mortality. The joint effect of scorch height and beetle presence was marginally significant as a predictor of tree mortality ($p = 0.09058$). This suggests that there are likely other variables that predict tree mortality in combination with beetles, tree size, and fire intensity, such as competition amongst trees. Further dendrochronological analysis will be done in order to assess the temporal aspect of beetle infestations in this stand.

Abstract

Refugia influence the distribution of a non-native crab in an urbanized estuary

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Species invasions are escalating worldwide as coastal communities become increasingly connected. Native predators can control or resist invasion by non-native species and refuge habitat can modify those interactions. We aim to understand the distribution of invasive European green crab, *Carcinus maenas*, in San Francisco Bay (SF Bay) and whether this distribution is associated with predation and refugia. Previous unpublished work in SF Bay found higher abundances of *C. maenas* in high intertidal elevations with marsh plants and rocky structure. Crustaceans can also find spatial refuge from subtidal predators in higher elevation intertidal areas. We assessed crab distributions using depth-distributed trapping and by trapping inside and outside of high elevation refuge habitat. We also used tethered crabs in areas with and without structural refuge to determine if predation was associated with patterns in crab distribution.

During depth-distributed tethering we found that tethered *C. maenas* will bury into sediments of low elevation unvegetated mudflats but not in high elevation habitats, where structural habitat likely constrains burial. Therefore, we tested the effects of burying behavior on predation by tethering *C. maenas* with and without underlying mesh to experimentally impede burying in lower elevations with soft sediment at four sites: Two sites in SF Bay and two sites in British Columbia.

Results/Conclusions

As expected, depth-distributed trapping efforts found higher abundances of *C. maenas* in high intertidal elevations. However, depth-distributed tethering revealed no clear pattern in predation across elevations and sites. We found that *C. maenas* is more abundant in rocky habitats than mudflat areas without structure, and there are site-specific patterns in *C. maenas* use of cordgrass, dependent on habitat composition. However, results with tethered crabs did not show higher crab mortality outside of areas of structural refuge.

The discrepancy in crab use of refuge habitat and low predation may be due to variable crab behavior across heterogenous habitats that may preclude assessment of relative predation. Experiments in which burying was prevented by mesh showed greater mortality by predation than without mesh in SF Bay mudflats suggesting higher potential predation in low elevations than originally thought. Alternatively, fluctuating physical and biological regimes associated with highly altered, urbanized estuaries such as SF Bay may decouple prey responses from predator distributions, causing crabs to concentrate in high elevation refuges regardless of the presence of predators. These results highlight the importance of evaluating the interaction of habitat

characteristics, prey behavior and predation to better understand invasive species distributions.

Abstract

Variation in ground fish species responses to marine protected areas

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

The California Collaborative Fisheries Research Program (CCFRP) is a statewide effort to collect robust fisheries-independent data through catch and release fishing in marine protected areas and reference sites in collaboration with volunteer anglers and commercial fishing vessels. Fishes were randomly sampled in each MPA and comparable reference site containing rocky reef habitat and similar depth range, and fishing time was recorded in each grid cell to measure effort. Standardized fishing methods allowed for comparisons of ground fish populations throughout the state and over time. We report results from two pairs of marine reserves and reference sites that we surveyed since 2017 along the northcentral coast, including mean length, and catch-per-unit-effort (CPUE). We addressed two questions: 1) Does reserve designation impact fish populations? 2) Which species'-specific responses were strongest?

Results/Conclusions

After just three years, fish CPUE was generally greater in the Bodega Head and Stewarts Point State Marine Reserves than in paired reference sites, though abundance and gains varied by species, site, and year. When species were separated by ecological guild into, water column fish (frequently schooling species, with shorter lifespans, that occupy a range of depths) and bottom fish (demersal, longer-lived, solitary species), the groups varied in their responses to marine protected areas depending on location. At Bodega Head, bottom fish had higher CPUE in the MPA than reference sites, while water column fish had higher CPUE in reference sites than MPA. The Bodega Head MPA may be more effective at protecting bottom fish than water column fish. Categorizing species based on ecological guilds helps one better understand MPA effectiveness based on ecological characteristics of groundfish.

Abstract

Saving FACE: A low-cost alternative for plant CO_2 enrichment experiments

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

The fate of forests and the carbon they contain is critical to determining future climates. Trees are important carbon stores because of their size and longevity, but for these same reasons, they are difficult to study in manipulative experiments. Growth chambers introduce undesirable artifacts to the growth environment. Free-Air CO_2 Enrichment (FACE) is representative of natural conditions, but expensive. Due to the tight coupling of CO_2 with other limiting factors in photosynthesis (water, light, nutrients), environmental stressors must be studied in combination; however, FACE is so expensive that diverse study designs have not been possible. We developed a low-cost alternative for testing the effects of elevated CO_2 on tree seedlings, to study their responses to future climates.

This summer, we will conduct a pilot study treating valley oak (*Quercus lobata*) seedlings with elevated (700ppm) CO_2 levels. Plants will be grown in an outdoor plot in Davis, California, with screens around each sub-plot to aid in CO_2 control. The plant microenvironment will be minimally affected due to turbulent mixing of air within the plot.

Over the course of 12 weeks, we will measure plant height, stomatal conductance, and chlorophyll fluorescence. Before and after the experimental period, we will measure light-response curves for a subsample of plants. After harvesting, we will measure biomass, root length, and stomatal density.

Results/Conclusions

In this pilot study, we will build CO_2 enrichment apparatus for six plots, each containing 10 seedlings. There will be two replicate plots at each of three treatment levels: ambient CO_2, elevated CO_2, and negative control. CO_2 will be continuously pumped into the elevated plots, with levels monitored by a LiCOR 840 and CR3000 datalogger. Preliminary testing of the CO_2 control apparatus shows it is capable of maintaining a mean concentration of 707.5 ppm (sd = 54), with a minimum of 513 and a maximum of 1085 ppm. These numbers compare favorably to similar experiments in the literature (e.g. Leadley et al. 1997) and are significantly better than the control afforded by a conventional FACE design.

Our modular, highly portable design can be used to greatly expand the scope of FACE studies across different plant types and ecosystems. We plan to apply these methods in forest systems as diverse as Sierran mixed conifer and northeastern mixed hardwood forests. Our data will help us determine the best applications of our design, to advance understanding of plant physiological responses to climate change.

Abstract

The impact of extreme climate events on extinction risk and the role of evolution

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Extreme climate events such as hurricanes, droughts, and floods act as drivers of ecological and evolutionary change. These events are expected to increase in intensity and frequency in the future. We explore how a population's ability to rapidly evolve affects population size and extinction risk in the context of extreme events of varying intensity, duration, and frequency. These explorations are based on analytical approximations and numerical simulations of an individual-based model that fuses the infinitesimal model of population genetics with a density-dependent demography model.

Results/Conclusions

We find that when an extreme event is sufficiently short in duration, greater heritability results in a stronger evolutionary response and greater maladaptation when the event ends, slowing population recovery and increasing the probability of extinction. Alternatively, when an extreme event is sufficiently long in duration, heritability often helps a population persist, a finding consistent with the classical evolutionary rescue theory. Also, when populations experience repeated extreme events, heritability increases extinction risk, unless the events are temporally autocorrelated. Our results highlight the importance of accounting for the intensity, duration, and frequency of extreme events when assessing the role of evolution on population recovery.

Abstract

The fate of biological soil crusts and their plant communities after fire: A meta-analysis

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Fire is a global disturbance that is predicted to increase in frequency and severity in many parts of the world due

to climate change. As such, there is an increasing need to understand how ecosystem components respond to this disturbance. As fires are heterogenous across at local and global scales, it is often difficult to describe the overarching effects of fire on ecological communities. Furthermore, many communities are often overlooked in fire studies despite having a substantial effect on ecological function and the adjacent communities. One such community is biological soil crust (biocrust). Biocrusts are composed of micro and macro-organisms bound to the soil surface and are thus directly exposed to the heat of the fire. These communities also interact directly and indirectly with the surrounding vegetation by modulating seed survival, nutrient cycling, and soil stability. The goal of this study is to synthesize and analyze existing data elucidating the recovery of biocrust and vegetation cover following fire at the global-scale and suggest avenues for future research. We performed a meta-analysis of studies from 1900-2019 to specifically address the response of biocrust and their associated plant communities after fire and determine the moderating factors governing their response.

Results/Conclusions

We obtained 289 biocrust experiments from 17 unique studies. Five of those studies also measured plant cover resulting in 326 vegetation experiments. Biocrust and plant communities responded differently to fire. Although biocrust cover was reduced by 74% ($P<0.001$), this result is confounded by high between study heterogeneity indicating biocrust response to fire may be highly site specific. The plant communities in this study were not affected by fire, with notable exceptions. Exotic, annual grasses responded negatively ($P<0.001$) and perennial grasses, regardless of native status, responded positively to fire ($P<0.001$). Time since fire, fire type, and climate were not significant moderators for either community. Finally, although this was a “global analysis”, 81% of the studies occurred in the United States and all the studies were in either grasslands or shrublands. This is not characteristic of the global distribution of biocrusts and is thus particularly biased towards North American shrublands. Given this, we suggest future research should: 1) increase the number of studies in underrepresented ecosystems; 2) determine the relationship between vegetation fire characteristics and the biocrust community; 3) determine the appropriate scale to test these relationships and 4) consistently report fire severity, frequency, and history in ecological fire studies.

Abstract

Effects of experimental watering and warming on herbivory across a gradient of precipitation

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Climate change is affecting both geographic ranges and interspecific interactions. Range limit theory predicts that climatic effects on ranges limits will depend on both abiotic stress and biotic interactions. We examined the effects of experimental watering and warming on leaf water content and herbivory rates on a native perennial plant, pacific silverweed (*Argentina anserina ssp. pacifica*), across a gradient of precipitation in coastal California.

Results/Conclusions

We found that watering increased leaf water content at both wetter and drier sites, but only increased herbivory in drier conditions. Warming increased herbivory irrespective of local climate. Range limit theory (species interaction-abiotic stress hypothesis) predicts that the impacts of abiotic stress and biotic interactions trade off across stress gradients, with abiotic stress being more influential at the drier edge of the range. Our results were consistent with this expectation. Given predictions that the study locales will become warmer and drier with climate change, our results suggest that the effects of warming and drying on herbivory may counteract each other in drier regions of the range of *Argentina anserina*, while in wetter regions warming may increase herbivory without a corresponding decline due to drying.

Abstract

Phenological responses to variable timing and frequency of herbivory in a native wildflower

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

In the face of rapid global change, a crucial question in ecology and evolution is how species will respond to changes in climate and whether they will be able to adapt quickly enough to persist under novel abiotic and biotic conditions. Changes in plant phenology and herbivory regimes are already occurring due to climate change and have the potential to impact species interactions, community structure, and biodiversity. However, little is known about how within-species differences in phenology affect adaptation and persistence. Here, we examine population-level responses to herbivory regime in *Streptanthus tortuosus*, which occupies a wide range of environments and displays remarkable morphological and physiological variation. We conducted a common garden experiment mimicking mammalian herbivory on individuals from three alpine populations of *S. tortuosus* to determine the effects of varying timing and frequency of herbivory on phenology, fitness, and life history.

Results/Conclusions

Our results suggest that timing and frequency of herbivory significantly affects both flowering time and fitness. Individuals that experienced herbivory flowered significantly later than controls, and individuals experiencing later or more frequent herbivory experienced the most pronounced delays in flowering. Additionally, herbivory depressed fecundity in all treatments, and individuals exposed to more frequent herbivory experienced a significant reduction in fecundity. This suggests that plants are unable to compensate when herbivorized, especially when tissue damage occurs multiple times throughout the season. Plants were also more likely to survive for longer periods of time in response to herbivory (significantly so if herbivorized more than once), potentially leading to increased perenniality and iteroparity. Overall, results suggest that individual variation in the timing and frequency of herbivory impacts population-level variation in phenology, fitness, and life history. Future plant phenological responses to climate change will depend on how the timing of biotic pressures interacts with changing environmental conditions. If plants and their herbivores respond differently to changing environmental cues as summers become drier and hotter in alpine regions, such varying responses may alter temporal overlap between plants and herbivores, affecting plant fitness and persistence. Understanding the abiotic and biotic factors that currently drive phenological responses is essential for accurately predicting the potential for adaptation to future climate-induced environmental change.

Abstract

Long term priority effects in grasslands and the disruptiveness of drought

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

The high variability of California's stable annual-dominated grasslands defies prediction of community trajectories by traditional frameworks of succession. This makes management goals such as maintaining rangeland forage, restoring natives, and controlling noxious weeds (medusahead – *Elymus caput-medusae* & goatgrass – *Aegilops triuncialis*) challenging. Priority effects (i.e. when the first species to arrive alters the trajectory of the community) are an assembly mechanism currently being explored to better understand community change. However, as grassland communities influenced by the yearly variation in drivers such as litter and precipitation, we need long-term, field based studies to determine the importance of priority. For each of the three main grass groups in California grasslands (native perennials, naturalized exotic annuals, noxious annual weeds), we investigated whether a) temporal priority leads to maintained cover long-term, b) priority leads to resistance to invasion by other plant groups, and c) how strong priority effects are against extreme drought. We measured composition annually for 12 years in experimental grassland plots that were seeded with various mixtures of native, naturalized, and noxious invasive plants that were allowed to be naturally invaded by species included in the study design. Plots experienced the extreme drought of 2011-2014 and the historic wet year of 2017.

Results/Conclusions

In native-only-planted plots, natives survived severe climatic swings – drought decreased their cover, but they recovered to high abundance afterward. This dip in cover decreased their resistance to naturalized grasses but the natives were able to keep the noxious weeds out, likely due to their functional similarity in phenology of soil moisture use. Naturalized exotic-only-planted plots had similar trends in cover in relation to the drought but were not able to resist invasion by the noxious weeds. These results suggest that planting native grasses and giving them priority will lead to long-term native persistence and continuous noxious weed suppression, even under the extreme conditions of climate change. Thus native grassland restoration should be a priority on the invasion front of these damaging noxious weeds.

Abstract

Tree recruitment and forest expansion following reforestation in the western Sierra Nevada, CA

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

In post-wildfire landscapes in the western Sierra Nevada, the availability of live, reproductive trees is a strong predictor of conifer regeneration. Planting small “founder stands” has been proposed as a means of establishing future conifer seed sources in high-mortality areas where reforestation is difficult at scale. However, certain post-fire successional processes (e.g., the growth of competing vegetation) are also known to inhibit tree establishment and growth, and these processes may become dominant before planted trees become reproductive. Thus, it is unclear whether a planted founder stand that produces viable seed could plausibly result in seedling establishment and forest expansion in this system. We investigated this by conducting an observational field study testing the contribution of now-reproductive planted trees relative to site characteristics in driving conifer seedling recruitment in unplanted areas. At three locations in the western Sierra Nevada that were planted 22-25 years ago, we surveyed conifer regeneration in transects that crossed plantation boundaries, characterizing tree recruitment, competing vegetation, and proximity to seed sources.

Results/Conclusions

We modeled seedling recruitment as a function of distance to the nearest plantation, distance to other seed sources, competitive environment, and other environmental characteristics that could affect seedling establishment, and we focused analysis on recruitment of trees that were 10 years old or younger (i.e., those that established after plantation trees became reproductive). Seedling recruitment of this younger cohort was negatively correlated with the distance to plantation edges ($p < 0.01$), which suggests that plantations do contribute to tree establishment outside of the planted area. We did not find a significant effect of shrub cover nor overstory cover on recruitment, leading us to reject the hypothesis that shrub cover limits recruitment even when seeds are present.

We had focused the study on areas that had high post-fire tree mortality in an effort to distill the specific contribution of planted trees rather than trees that had survived the wildfire; however, we still found that distance to surviving trees was a significant predictor of recruitment in our plots ($p < 0.05$). Thus, the influence of plantations on long-term recruitment and forest expansion is happening alongside natural regeneration from large, surviving trees. Collectively, these results suggest that plantations may be a viable option for catalyzing tree recruitment in unplanted areas, but this strategy may be most relevant in areas where large, surviving trees are not available as seed sources.

Abstract

Three big questions in ecology: Transient dynamics, changing environments, and human-environment interactions

Alan Hastings, Department of Environmental Science and Policy, University of California, Davis, Davis, CA

2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Classical ecological approaches could be caricatured as focusing on long term dynamics of ecological processes in environments that are not changing in a directional way with limited human interference. Despite classic work, beginning with views that communities were always changing and not reaching steady states, more recent work on impacts of climate change, and work on ecosystem management and management of renewable resources, much more work is needed to develop the underlying theory to deal with three big questions that arise from changing each of the three paradigms indicated. 1) What are the dynamics of ecological systems on ecologically realistic time scales? 2) How do populations and ecosystems change in response to a continually changing environment? 3) What is the proper way to manage ecosystems?

Results/Conclusions

Naturally, the answers and approaches to these three challenges are intertwined. However, in all cases, new mathematical approaches and new ways of integrating empirical and theoretical work are needed. New mathematical approaches as well as new ways of gathering and interpreting data, and providing new ways of managing natural systems are all part of the solution. Recent progress has been made in developing approaches for dealing with dynamics on intermediate time scales, on dealing with systems where explicit dependence on time is included, and on using new approaches to manage complex systems. I will present both general results, and results applied to specific systems.

Abstract

Elephants mitigate the (Mostly Negative) effects of cattle in a Kenyan savanna rangeland

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Across the globe, wildlife and livestock share much of each others' landscapes, but most wildlife research is carried out in protected areas. Livestock often compete with wildlife, and can have other (mostly detrimental) effects on ecosystem functions, especially at high densities. We report here on results from the Kenya Long-term Exclosure Experiment (KLEE), designed to tease apart the separate and combined effects on a savanna rangeland of livestock, wildlife, fire, and drought/seasonality. For the past 25 years, we have been manipulating the presence and absence of cattle, meso-wildlife, and mega-herbivores (elephant and giraffes) in 18 four-hectare plots in Laikipia, Kenya. We regularly measure vegetation, dung deposition (vertebrate use), and soil chemistry.

Results/Conclusions

One of our most striking set of results is that elephants reduce many of the impacts of cattle on this system. The impacts of cattle that are mitigated by elephants include 1) decrease in grass cover, 2) decrease in habitat use (competition) by multiple species of wildlife, 3) increase in primary productivity, 4) decrease in soil nitrogen and phosphorus, 5) bush encroachment, and perhaps 6) decrease in rodent populations, and 7) increase in termite abundance. One cause of these mitigations is that cattle remove less grass in plots accessible to elephants, likely because of an elephant-induced shortage of N-rich forage. However, there may be other pathways of mitigation as well, including reductions in tree densities by elephants. These results are a subsample of the rich, complex, and often unexpected patterns that are being revealed by an experimental design that crosses multiple interacting stressors (e.g., multiple herbivore guilds, fire, livestock intensity, soil fertility, and drought cycles).

Abstract

The good, the bad, and the vectors: how habitat influences the functional role of birds in

agroecosystems

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Some birds are viewed as pests and vectors of foodborne pathogens in farmlands, yet birds also benefit growers by consuming pests. While many growers seek to exclude birds from their farms, few studies ask how the functional role of birds shifts across farming contexts. We ask how local (*i.e.,* hedgerows, multiple crops) and landscape *(e.g.*, more non-crop habitat surrounding farms within 1.5km) level diversification influence the likelihood of different bird species to function as beneficial, pest, and vector species. We captured birds and collected fecal samples, and surveyed crop fields for fecal contamination, on 20 California strawberry farms that varied in local management practices and landscape context. We characterized bird diets using a combination of metabarcoding and targeted PCR to screen for a key pest (*Lygus hespersus*), strawberries, arthropod natural enemies (*e.g.,* spiders, ground beetles *etc.*), and foodborne pathogens (pathogenic *Escherichia coli*, *Salmonella*, and *Campylobacter*) in bird feces. We tested the effect of local and landscape diversification in determining the probability that different bird species consumed pests, potentially disrupted pest suppression by consuming arthropod natural enemies, damaged crops, and vectored foodborne pathogens.

Results/Conclusions

We captured 1,498 birds, representing 74 species, and collected 1,328 fecal samples. We found very low incidence rates of *E. coli* and *Campylobacter* (<4%), and did not detect *Salmonella* in any samples. *E. coli* incidence was weakly negatively correlated with seminatural habitat, such that birds were less likely to carry *E. coli* on farms with more conserved habitat in the surrounding landscape. *Campylobacter* incidence was significantly lower on farms surrounded by more seminatural habitat. We also found that fecal contamination in crop fields did not increase with seminatural habitat. From preliminary analyses, we also found that birds were most likely to function as pests (*i.e.,* consuming strawberries) on monoculture farms in landscapes with little remaining seminatural habitat. Finally, our preliminary analyses also indicated that the influence of seminatural habitat surrounding farms had differential effects on invertebrate pest and natural enemy consumption for different bird species. In recent years, market pressures have encouraged farmers to remove non-crop vegetation in an effort exclude wildlife from farms and mitigate food safety risks. Our results suggest that habitat removal does not increase pathogen prevalence or fecal contamination, and could exacerbate crop damage. Taken together, our findings suggest that conserving natural habitat in farming landscapes may help to limit the role of birds as both pests and vectors on farms.

Abstract

A framework that identifies and prioritizes how ecologists are testing for predation-risk effects in the field

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Despite the plethora of studies examining predation risk effects that result from prey changing traits in order to reduce predation risk, it is not well understood whether predation risk effects alter prey populations (i.e., non-consumptive effects, NCEs) or indirectly affect populations the prey interacts with (i.e., trait-mediated indirect effects, TMIEs) in natural settings (i.e., those not manipulated experimentally). As such, it is unclear if in natural

systems NCEs and TMIEs are inconsequential relative to consumptive effects of predators. We performed a comprehensive review of the literature to screen published evidence of NCEs and TMIEs in natural settings, and to categorize the approaches used to examine this problem. We developed a framework to differentiate studies by (a) the type of predation-risk effect examined, and (b) the nature of the field component aspect of the study. We identified all studies of NCEs and TMIEs that had a field component, and differentiated whether papers explicitly examined a surveyed field patterns of demography, abundance or density.

Results/Conclusions

Our review from 1990 to 2018 produced >450 papers that examined the consequences of trait (phenotype) changes to predation risk (i.e., NCE/TMIE), with a 20-fold increase in publication rate over the time period. One third included a field component. Very few of the NCE studies examined an unmanipulated field pattern of prey abundance (< 1%), or of prey fitness measures such as fecundity (~6%). Although a bit higher, there were also few TMIE studies that examined a surveyed field pattern. Rather, the great majority of studies examined factors that influence risk effects in more controlled settings with some form of manipulation e.g. they examined the influence of prey density, evolutionary history, predation hunting mode, etc. While these latter types of studies are important, we argue that they are disproportionately represented and that demonstrating the contribution of NCEs and TMIEs to field patterns is being relatively neglected. Future research needs to shift more towards examining the importance of risk effects on natural populations, and in particularly those that evaluate the influence of risk effects on surveyed field patterns. We review and discuss the strengths and weaknesses of different approaches used to evaluate the contribution of risk effects generally, and more specifically to surveyed field patterns. Developing such approaches is critical to advance this exciting sub-field in ecology forward in order that it can be applied to management and conservation challenges.

Abstract

Wild robots: Developing DIY technology to investigate soil carbon flux in a long-term, landscape-scale, large herbivore exclosure experiment in a central Kenya savanna

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Large herbivores impact carbon cycling in myriad ways, including by impacting a landscape's assembly and structure. It is therefore necessary to explore carbon cycling at the scale of landscape features, to better predict how large herbivore impacts may scale up. However, it is often prohibitive (logistically, climatically, financially) to measure carbon dynamics at fine spatial and temporal scales using traditional manually-operated methods.

I interrogated the effects of large herbivores on carbon cycling in a large-scale exclosure experiment in central Kenya by manually measuring *in situ* soil carbon flux. However, these data and supporting datasets illuminated the need for significantly greater spatial and temporal resolution to characterize soil carbon flux in this savanna.

To capture such resolution I developed and deployed a network of inexpensive, DIY, autonomous soil carbon flux chambers ("fluxbots"). Fluxbots collected hourly flux measurements at each of three key landscape features (open soil patches, the surface of active termite mounds, and beneath the canopy of the dominant tree species *Acacia drepanolobium*), across experimental treatments that allow all large vertebrate herbivores or none, for 2.5 months spanning a transition from dry to wet season.

Results/Conclusions

In situ soil carbon flux data manually collected over three dry seasons reveal treatment-level effects that vary from year to year; from increasing flux rate with decreasing large herbivore presence, to no difference between treatments. This variability is likely influenced by changing environmental conditions, like drought and rainfall. Complementary datasets demonstrate differences between landscape features within herbivore treatments, like higher soil microbial biomass and respiration rates from soils beneath tree canopies, and higher soil carbon at

termite mounds. Such results indicate that highly-resolved data, temporal and spatial, is necessary to characterize soil carbon flux.

A synchronized network of fluxbots captured 2.5 months (Aug-Oct 2019) of hourly flux data, across herbivore treatments and the features within each. Atmospheric CO_2 and flux rates follow cyclical diurnal patterns, indicating that flux is temporally dynamic, and that this high-elevation, seasonally dry savanna's changing environmental conditions are influential. Such highly-resolved data could not have been collected manually, demonstrating the importance of innovating inexpensive sensors in improving accessibility and resolution of flux data. These and correlated data demonstrate that savanna carbon flux is extremely dynamic, and likely influenced by patterns in environmental conditions over time and the spatial distribution of features.

Abstract

Can disease transform a trait-mediated system to a density-mediated one? Ecosystem responses to the collapse of vicuñas in the high Andes

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

The impact of antipredator behavior on resource biomass and distribution has been widely demonstrated in laboratory settings, yet tests of the magnitude of trait-mediated indirect effects (TMIE) in wild populations are rare. One of the few wild systems where TMIEs have been strongly supported is a model single-predator (puma), single-prey (vicuña) system in San Guillermo National Park, Argentina, where spatial patterns of predation risk increased biomass of vegetation in herbivore exclosures, but only in refuge habitats. However, a recent mange outbreak resulted in a profound collapse of the vicuña population (99% decline), transforming a TMIE to a density-mediated indirect effect (DMIE) on forage plants. Here, we quantify the magnitude of the cascading effects of this shift and test two alternative hypotheses to explain its mechanism: 1) mange makes vicuñas more vulnerable to puma predation (i.e. pumas remain the primary top-down force, but their major impact shifts from being trait- to density-mediated); or 2) mortality in vicuñas is dominated by the direct impact of mange (i.e. mange displaces pumas as the primary top-down force).

Results/Conclusions

We did not observe a shift in puma predation distribution (i.e. more kills in the refuge) or magnitude (i.e. higher kill rates) in concordance with the mange epidemic. Therefore, we did not find evidence that mange changed the relationship between pumas and vicuñas, but rather that mange itself was the driver of the DMIE. We found that increases in greenness (measured by the Normalized Difference Vegetation Index, or NDVI) and forage biomass occurred only in refuge habitats where TMIEs had been documented, indicating a breakdown in the TMIE. Time since mange was a strong predictor of NDVI increase, but only in refuges, and forage biomass increased by over 1000% in refuge habitats (a similar magnitude increase as found in earlier exclosure experiments). The magnitude of the effect indicates that the strength of the mange-induced DMIE on forage was similar to that of the previous predator-induced TMIE. Our results suggest that disease can transform a predator-induced TMIE-dominated system into a disease-induced DMIE-dominated system. We also show how controlled experiments can be used to examine the magnitude of different mechanisms of top-down forcing when confronted with environmental change.

Abstract

Elevational movements of songbird species within the breeding season: How resource availability and climate drive movement patterns

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

A dominant paradigm in ornithology is that passerines arrive on their breeding grounds, establish a territory, and remain on that territory for the majority of the breeding season. Our research on passerines in the mountains of the Great Basin, USA, challenges that paradigm. From 2001-2019, we conducted avian point-counts at 538 sites throughout the western and central Great Basin. At the same sites, we collected data on vegetation indices, microclimate, insect abundance, availability of fruit and seeds, snow melt timing, and primary productivity (measured as the normalized difference vegetation index).

Results/Conclusions

We used multinominal, single-species N-mixture models to examine elevational movements of 27 passerine species. Some species, including Lazuli Bunting and Black-throated Gray Warbler, moved upslope during their breeding seasons, whereas others, including Spotted Towhee and Fox Sparrow, appeared to move downslope. We tested relations between site variables and the abundances of species that moved elevationally during their breeding season. For example, primary productivity and fruit and seed availability had a significant and positive relation with abundance of Lazuli Buntings, suggesting their upslope movement is related to resource availability. Directional elevational movement during the breeding season may change understanding of reproductive ecology, effects of climate change on avian populations, and single-species occupancy and abundance modeling.

Abstract

The influence of human disturbance on encounter risk: A meta-analysis of temporal partitioning in mammalian predators and their prey

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

The rapid expansion of human activity in the Anthropocene has broadly influenced the distribution and behavior of wildlife. Many studies have found that humans can displace animals in space and time and, alternatively, that animals can habituate or be attracted to humans in space and time. However, fewer studies have examined the consequences of human activity on the temporal overlap of predators and prey. We conducted a meta-analysis of studies that measured the activity patterns of mammal predators and their prey in response to human activity and infrastructure (n= 51, 121 pairs). We also present a conceptual framework to connect shifts in temporal overlap of predator-prey pairs to predictions of encounter risk and predation.

Results/Conclusions

Our preliminary meta-analysis revealed a stronger negative effect of human activity on predators than on their prey. Additionally, we found stronger support for the prey refugia hypothesis among predator-prey pairs with cursorial predators than in pairs with ambush predators. Still, our analysis indicates that many predator-prey pairs mutually avoid human activity and experience increased temporal overlap. We assessed how the type of human disturbance (i.e. infrastructure, recreation) and taxonomic traits (e.g. body size, trophic position) influenced the magnitude of predator-prey responses. These results highlight circumstances in which predators or prey respond positively, negatively, or neutrally to various types of human activity. We synthesize how altered temporal overlap can lead to various food web disruptions and alter patterns of energy intake within ecological communities.

Abstract

Tree planting the year following high severity wildfire gives tree seedlings a critical head start when competition from shrubs is intense

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Wildfires in the mid-elevation forests of California's Sierra Nevada mountain range have massively increased in size and intensity over the past half-century due to a century of fire suppression and possibly climate change. Disturbance on this scale was rarely seen in the Sierra Nevada prior to initiation of fire suppression. As a result, post-fire forest tree regeneration has become weak in many areas, leading forest managers to invest in tree planting as a strategy to hasten forest recovery after fire. Despite the critical importance of tree planting for forest recovery, it remains unclear how environmental variation in tree stress determines natural regeneration versus planting success.

Results/Conclusions

To address this gap, we joined efforts with the U.S. Forest Service to ask how variation in the physical environment (e.g., temperature, precipitation, light intensity, etc.) and competition from shrubs impact natural regeneration and tree planting success after forest fires throughout the Sierra Nevada. We found that natural regeneration is lowest at the hottest, driest sites and that tree planting can provide a moderate boost to forest recovery under these conditions. We also found that the timing of tree planting matters but depends on competition from shrubs. In places where shrub competition is intense, tree planting is much more successful if planting occurs the year immediately following a fire (the soonest that it is practical to plant). Alternatively, in places where shrub competition is weak, waiting a few years to plant trees until some shrubs establish actually facilitates tree survival, perhaps by providing shelter from harsh conditions. Overall, we recommend forest managers prioritize the hottest, driest sites for reforestation projects and plant trees as soon as possible where competition from shrubs will be most intense.

Abstract

Combined pesticide and resource stressors impair wild bee reproduction and behavior

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Bees and other beneficial insects experience multiple stressors within agricultural landscapes that act together to impact their health and diminish their ability to deliver the ecosystem services on which human food supplies depend. Disentangling the effects of simultaneous flowering resource scarcity and pesticide exposure is a primary challenge in understanding how to promote their populations and ensure robust pollination and other ecosystem services. Negative effects of systemic pesticides on bee survival and reproduction are well documented but based largely on correlative field and lab studies. We used a crossed design to quantify the individual and combined effects of food resource limitation and pesticide exposure on the survival, nesting, and reproduction of the blue orchard bee *Osmia lignaria*. We established nesting females in 16 large flight cages using a crossed resource x pesticide design; cages contained spring wildflowers at high or low densities, treated with or without imidacloprid. We monitored nesting activity and brood cell construction daily and used video footage to measure foraging trip times, nest usurpation and defense, and activity patterns across treatments.

Results/Conclusions

Pesticides and resource limitation acted additively to dramatically reduce reproductive fitness in free-flying bees. Of the female *O. lignaria* that initiated nesting, those exposed to imidacloprid produced 42% fewer surviving offspring than unexposed controls, and bees with low resources produced 26% fewer surviving offspring than bees with abundant resources. In addition to direct effects on reproduction, combined resource and pesticide stressors led to male-biased sex ratios, further limiting reproductive output. Stressed bees also constructed nests slower, spent more time foraging, and nested for fewer days than unstressed bees. We demonstrate that pesticide and resource stressors are additive, which may enable us to make preliminary predictions about the effects of environmental change from univariate experiments. Furthermore, this work directly addresses the lack of field studies examining multiple demographic responses for solitary bees. Our results emphasize the importance of considering multiple drivers to inform population persistence, management, and risk assessment for the long-term sustainability of food production and natural ecosystems.

Abstract

Impacts of honey bee introductions on the pollination of a Sierra wildflower

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods:

While many bee species are declining, managed species, such as honey bees, have been introduced into novel ecosystems across the globe. Many studies support the claim that introduced honey bees compete with native bees for floral resources. However, little is known about how honey bee introductions affect native plants. Studying the impact of honey bee introductions is an important issue for native plant conservation because honey bee presence can alter native bee community composition, abundance, and behavior, which may disrupt native plant pollination. We studied the impact of honey bee introductions on the pollination and reproduction of a Sierra wildflower, *Camassia quamash*. We sampled meadows along a gradient in honey bee abundance generated by experimental honey bee introductions and pre-existing apiary locations to ask whether increased honey bee abundance in the landscape affected plant-pollinator interactions, the composition of the community of insects visiting focal *C. quamash* plants, and patterns of pollen deposition and seed set. We also investigated whether honey bees were good pollinators of *C. quamash* by conducting a separate experiment in which we manipulated the number of honey bee visits flowers received.

Results/Conclusions:

We found that increased honey bee abundance in the landscape leads to increased visitation to *C. quamash* by honey bees and decreased visitation by native bees, potentially indicating competitive exclusion. Preliminary results also suggest that honey bees are ineffective pollinators of *C. quamash* on a per visit basis and this inefficiency is not compensated for by an increased number of honey bee visits. The replacement of native bee visits by honey bee visits correlated with reduced seed set, suggesting that honey bee introductions in the Sierra may have negative effects on the pollination of *C. quamash*. This research demonstrates that honey bee introductions can have negative effects on plant pollination when they lead to an over-representation of visits from ineffective pollinators.

Abstract

Landscape models show the potential for combined pollinator and natural enemy ecosystem services

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Supporting populations of organisms that provide pollination and biological pest control is a key component of

ecological intensification to promote sustainable agriculture. Because insect pollinators and natural enemies share certain habitat needs, scenarios that benefit both may depend on spatio-temporal congruence of these habitats and the relative mobilities of the different organisms. Most studies that document landscape effects on such mobile ecosystem providers have focused on one group or the other. Furthermore studies find that landscape context can interact with on-farm agronomic practices to determine the direction and magnitude of outcomes for pollination and pest control services, as well as the organisms that provide them.

We used spatially explicit models of pollinators and natural enemies to predict the delivery of pollination and pest control across landscape configurations (grain size) and contrasting crop management strategies (till versus no-till). The framework merges previously-published process models of pollinators and natural enemies, respectively, which predict service delivery based on specific crop and non-crop habitat qualities and organism mobility. We use the framework to identify potential landscape scenarios and specific actions that co-benefit services versus scenarios that reduce one or the other leading to a service disservice trade-offs.

Results/Conclusions

Crop management interacted with landscape configuration to affect on-crop pollinator abundance. In simple (coarse-grained) landscapes crop management produced contrasting outcomes with pollinator abundance much greater on no-till than till fields. This occurs because tilling prevents bees from nesting within crop fields, thus they must fly from natural habitat to provide pollination. In complex (fine-grained) landscapes natural habitats were generally closer to all parts of the crop so tillage mattered less. Natural enemies responses were more consistent across landscape configuration although they were generally more abundant in no-till fields. Highly mobile natural enemies responded more similarly to pollinators, than those with limited mobility. The importance of landscape complexity for providing co-benefits to pollination and pest control was clearest for tilled fields. Pollinators and natural enemies both benefited from increased complexity. However the potential for co-benefits on no-till fields was inconsistent and depended on the relative mobilities of natural enemies and pollinators. At one extreme, increasing complexity produced potential trade-offs between pollinators and low-mobility natural enemies. Our models highlight the interplay of local and landscape factors in determining multiple ecosystem services. Strategies to promote multiple services will benefit from understanding the congruence of habitat needs and mobility of service-providing organisms.

Abstract

Intraspecific variation in thermal physiology of West-Coast Chinook salmon

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2020 ESA Annual Meeting (August 3 - 6)

Background/Question/Methods

Fish populations, and salmonids specifically, are known to match their physiology to the local thermal environment. Physiological variation between populations can be a result of acclimatization and local adaptation. Chinook salmon (*Oncorhynchus tshawytscha*) exist across a large latitudinal range, with individual populations experiencing a variety of temperature regimes. California Chinook salmon in the Central Valley live at the southern species range and experience temperatures warmer than northern populations. Therefore, they may exhibit a physiology suited for warmer waters. However, without controlled comparisons our understanding of the thermal capacity of Chinook salmon, and the potential for population-specific thermal adaptation remains limited. We hypothesized that across a latitudinal gradient, southern (California) populations would exhibit a more ‘warm-adapted’ physiology than Northern populations (Oregon and Washington).

Over the course of three years, we reared juvenile Chinook salmon from eight hatchery populations spanning the states of California, Oregon and Washington. Each population was reared at three acclimation temperatures (11, 16 and 20°C) to explore interpopulation variation in acclimation capacity and thermal physiology. We measured temperature dependent growth rate, acute thermal tolerance and aerobic metabolic scope in order to assess whether Chinook salmon populations exhibit intraspecific variation in thermal capacity and potentially local adaptation.

Results/Conclusions

Overall we found Chinook salmon across the sampled range to exhibit impressive thermal capacity, challenging the moniker of a ‘cold-water fish’. More specifically, our work found several patterns indicative of local adaptation among Chinook salmon populations. Within the Central Valley the Winter-run population, native to historically cold, high elevation rivers, exhibited thermal performance phenotypes suited for cooler waters with declining metabolic performance and growth when acclimated to warmer temperatures (16° & 20°C), however acute thermal tolerance remained high (~28-30°C). Our results also indicate that differences between populations are most apparent when populations are reared at warm (20°C) temperatures. While some evidence for a difference between populations along a latitudinal gradient exists, our results indicate that local environmental characteristics may serve as better predictors of population-specific thermal performance. This work has implications for how we manage and conserve at-risk salmonid populations in a warming climate.