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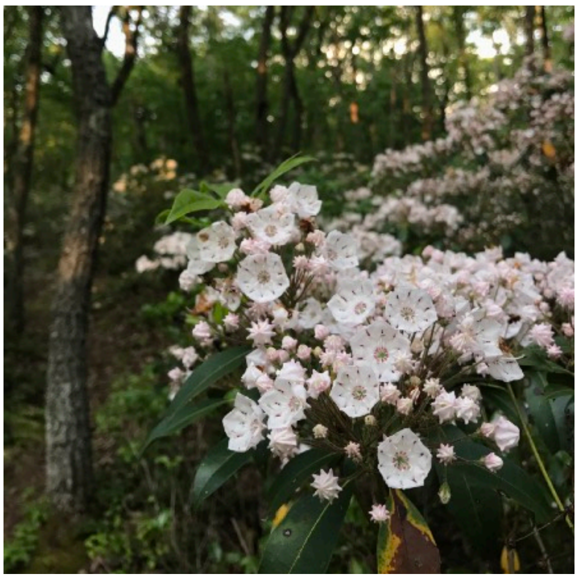
Notes from the Field

The biannual newsletter of the Intercollege Graduate Degree Program in Ecology
The Pennsylvania State University



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Mountain laurel (Kalmia latifolia) growing under a Chestnut oak (Quercus prinus) overstory in Rothrock State Forest. Photo credit: Warren Reed

Infectious Disease Dynamics in Yellowstone Wolves

by Ellen Brandell

The spring of 2005 began in a typical fashion in Yellowstone National Park (YNP). Wolves are born in April and cared for closely by their mothers and packs until the pups were more mobile and able to learn and explore. YNP wolf researchers can often observe this process thanks to Yellowstone's open valleys and high wolf abundance. Multiple dens were visible into the summer, but the typically joyful scene of pups emerging, playing, and growing was drastically interrupted. When the pups were only a few weeks old, they became lethargic, lost their appetites, and in extreme cases, suffered from neurological manifestations such as seizures. Survival of pups dropped to approximately one-third of its historical average; in some packs, no pups survived at all. This was the first closely observed outbreak of canine distemper virus in Yellowstone wolves.

Researchers that witnessed this canine distemper virus (CDV) outbreak had many questions. These questions led to extensive research about which pathogen and parasite infections YNP wolves have, how infections spread, and the impacts of these infections on individuals and the population. Specifically, the reintroduction of wolves into Yellowstone in 1995 following over six decades of absence allowed researchers to track the invasion of pathogens and parasites into a naïve host population and observe infectious disease dynamics through space and time.

YNP wolves and their pathogen and parasite communities are a prominent part of the ecosystem and food web. Many questions remain about how the consequences of infectious diseases in a top predator will percolate through the food web and if these effects can be detected. This is where my dissertation research enters. My research focuses on three main lines of inquiry:

- What are the dynamics of infectious diseases in a social carnivore species?
- Do the consequences of infectious diseases in a top predator impact their primary prey species, and if so, can we detect these impacts?
- Can top predators reduce infectious disease prevalence in prey populations by selectively removing infected individuals?

Wolves are a territorial, social species, and understanding infection dynamics within packs may elucidate the relationship between group size, population size, and infection prevalence, severity, and consequences. Once this relationship is established, I will investigate how the consequences of infectious diseases in the wolf population affect wolves' main prey species – elk. For example, evidence indicates that packs below an optimal size are more likely to decrease in size after experiencing mange infections via mortality and increased dispersal rates. Smaller packs are less effective hunters, thus mange infections may decrease wolf kill rates on elk. Yet wolves are not the only species with infectious diseases. In fact, ungulate diseases such as chronic wasting disease and brucellosis are increasing in the greater Yellowstone ecosystem and have notable population effects. Wolves may reduce the spread or prevalence of these infections by selectively removing infected, and potentially the most infectious, individuals from the herds because they are debilitated from the infection – this is called the "healthy herds hypothesis." Further complications can occur if there are infections within the wolf population as well. These questions require modeling to predict possible scenarios.

Ellen helping collar and collect data on a young female wolf.

Data is needed to answer my research questions! My data comes in two forms: unobservable and observable. Unobservable data is collected using serology, parasitology, and genetics, and we directly observe certain diseases by tracking uniquely identifiable wolves through time (e.g., Sarcoptic mange). Serology tells the story of that individual's infection history based on antibodies present in serum; parasitology, genetics, and observations reveal which pathogens an individual is currently infected with. Together, each is a piece of the puzzle to determining past exposure, current infectiousness, or future risk.

We collect blood and swabs (nasal, conjunctival, fecal) from roughly 15–20 wolves each winter during capture, which are used for serology, parasitology, and genetics.

You may be wondering: how does one catch a wolf? It is not an easy task! Wolf project researchers fly in a helicopter and dart wolves with tranquilizers from the air as the wolves weave through vegetation at high speeds. Once darted, the helicopter lands in a clear area, and researchers disembark and process the wolf. We outfit each wolf with a radio collar and collect data on body condition, age, and sex. Once the wolves awaken and rejoin their packs, we use their radio collars to track them using telemetry. This can be very tricky in the mountainous landscape. Once located, we use spotting scopes to observe the collared wolves, as well as uncollared but uniquely identifiable wolves in their packs.

Prey disease data are collected at wolf kill sites. Kill site investigation is like CSI for wildlife; we try to understand how the wolves were able to overpower their prey based on the topography and drag or blood marks. We also assess if the prey's condition may have weakened them to the predator. Finally, we look at what other animals may have taken advantage of a free meal on the landscape using tracks, scat, feathers, and hair. We find the most common visitors to carcasses that wolves have killed are coyotes, ravens, magpies, eagles, and grizzly bears.

If not scavenged, we take tissues to test for diseases. We also collect bone marrow, which provides information about the amount of fat, and therefore body condition, the individual had at death. These data are complemented with serological and histological data collected by neighboring state agencies and other YNP research teams. Together, we can determine the overall health of the elk population and the health of the individuals predated by wolves.

While each field of ecology has its own research impediments, disease transmission is unobservable, and often the symptomology of wildlife infections is too cryptic to detect. This is probably why, despite the ubiquity of diseases in wild animal populations, relatively little is known about these infectious disease dynamics. My goal is to help bridge the gap between wildlife ecology and disease ecology through my dissertation research. While I am at Yellowstone conducting research, please feel free to visit the park and observe the wolves!

Left: Ellen performing a necropsy (animal autopsy) on wolf-killed bull elk. Right: Using radio telemetry to track collared wolves.

REWINDING THE TAPE: MUSEUM SPECIMENS FOR EVOLUTIONARY GENOMICS: AN UPDATE FROM LASKY LAB POSTDOCS

Dr. Emily Bellis and Dr. Lua Lopez suited up to extract DNA from historical herbarium samples

Evolutionary ecology has fundamentally sought to answer the question of how organisms change through time and space in response to their environment. Typically, we make inferences about past events based on static genetic patterns in current populations and species. However, these genetic "snapshots" are limited in their ability to inform on underlying process because multiple processes can generate the same static patterns. The emerging field of ancient genetics can be understood as a "time machine" which provides extremely informative data on past genetic patterns. Ancient genetics is based on the idea that by studying old samples we can directly observe genetic changes over time. So far, this field has provided outstanding human and animal examples; yet, plant-focused studies offer major opportunities. Plant specimens offer some intrinsic challenges in tissue preservation and rapid DNA decay, relative to animal specimens. However, recent methodological and technological developments can now be used to obtain genetic data from vast herbarium collections revolutionizing the possibilities in plant evolutionary ecology. The following three examples show very exciting topics that can now be addressed using ancient plant genetics.

Striga hermonthica attached to host (rice) collected in Burkina Faso in 1992, currently stored at the National Museum of Natural History in Paris.

Dr. Lua Lopez: I am currently working the model species *Arabidopsis thaliana*. Using this model species, I will identify the genetic signature of adaptation processes occurred across time and space. Leveraging natural history museum collections, we have obtained samples across Eurasia collected throughout the past 200 years. These herbarium vouchers can be used to obtain morphological data which can be associated with the genomic information allowing us to decipher complex evolutionary patterns, for example, how land use influences population's structure or how populations response to environmental changes (e.g. climate change). Beyond the exciting science that this type of dataset can provide, working in this project has showed me the immense relevance museum collections have for researchers and how under-supported these institutions are.

Dr. Emily Bellis: I am currently working on a collaborative project that leverages herbarium specimens to understand local adaptation and evolution of host range in parasitic plants. The species we are studying, *Striga hermonthica* (giant witchweed), is a plant that parasitizes important cereal crops including maize, sorghum, millet, and rice and is a major constraint to food production in sub-Saharan Africa. By sequencing DNA from historical samples preserved in herbaria, and linking this genetic information to experimental work with current populations, we hope to identify genetic variation that might be important for enabling parasite adaptation to local agricultural practices over space and time.

Dr. Kathryn Turner: I use introduced and invasive plants to understand adaptation to novel environments and the process of invasion, a major component of global change. In my work, I utilize herbarium specimens collected throughout the course of an invasion as 'snapshots' of the genetic and phenotypic diversity available in the invaded range at that time. With this information, I hope to understand the key events necessary in the process of invasion, such as bottleneck or replacement events, admixture, or adaptation to novel biotic or abiotic conditions. I further use herbarium specimens to understand global, kingdom-wide, patterns of adaptation to novel abiotic conditions, such as climatic niche evolution, which may occur during invasions or with climate change.

Preditor-prey Interactions in Longleaf Pine

by Elyse McMahon

Fire is becoming more prominent across many landscapes throughout the world. It is a unique type of disturbance that can rapidly and profoundly alter vegetation quantity, quality, and structure. Fire regimes vary greatly among ecosystems, ranging from predominantly low severity surface fire, where intensity causes little change to the overstory vegetation, to stand replacing crown fire. At the Joseph W. Jones Ecological Research Center in Georgia, a two-year fire cycle is one of the key methods to managing the Longleaf Pine ecosystem. These prescribed fires are moderate in nature and do not shift the ecosystem to an alternate stable state, but create a dynamic landscape which changes as time-since-fire increases and vegetation regrows.

This dynamic landscape, and the changes thereafter, results in altered interactions between organisms that experience these fires. Within this study, I am focusing on predator-prey interactions in these changing landscapes. While predation can have direct impacts on prey populations, indirect effects, or the risk of predation, can drive changes in prey physiology and behavior. The consequences of indirect effects include decreases in reproduction, growth, immunity and ultimately negative impacts on population dynamics.

Elyse McMahon participating in a prescribed burn at the Joseph W. Jones Ecological Research Center.

Here at the Jones Center, I am testing the hypothesis that fire creates a dynamic predation risk landscape that alters individual prey responses and population level dynamics. Specifically, I am investigating 1) how fire and predation risk interact to alter prey physiological and behavioral responses over time, 2) how these changes influence individual fitness, and 3) how this in-turn scales up to affect population dynamics.

The purpose of this first field season is to collect pre-burn data and determine baseline values for my focal species, the eastern cottontail (*Sylvilagus floridanus*). Cottontails are an important component in the diet of multiple predators in this system, and, thus, are a major prey animal. Moreover, previous studies in other systems have shown that fire does not directly kill cottontails.

To conduct this study, I am using the predator exclosures the Jones Center established in 2003 along with their respective control sites that are of similar habitat composition. In each site, I am setting tomahawk live traps in the evening and checking them in the morning. Once I do catch a rabbit, I collect several measurements including weight, hindfoot length, sex, and age. I also ear tag each animal with a unique number to collect mark-recapture data.

In addition, I place a very high frequency (VHF) collar on each adult to track their movements and collect survival data throughout the field season. So far, I have caught 12 rabbits and collected ample data points to determine home ranges and survival. What's really cool about these collars is they send a mortality signal out if it hasn't moved in over 4 hours. The first rabbit I caught was cached by a bobcat. I was able to put a trail camera on the cache site to verify this and collect some interesting videos of bobcat behavior.

I am also collecting fecal samples the rabbits leave in the cage. These fecal samples will be used to analyze stress hormones (glucocorticoids) along with testosterone and progesterone. These physiological measures will enable us to determine how "stressful" the control sites are compared to the predator exclosures and eventually the stress of a fire.

To assess behavioral responses to predation risk and altered landscapes, I am using measurements of giving-up density (GUD) and video recordings of vigilance behavior. This method allows us to determine the perceived risk of an environment, which may coincide with how stressed rabbits are in both predator exclosures and control environments. However, it seems the small mammals in the areas also want to participate in the GUD studies, so this procedure may be altered in the future field seasons.

Elyse handling an Eastern Cottontail.

Besides doing all of this awesome field work, I was able to participate in a controlled burn on the property. This gave me the opportunity to learn how prescribed fires are conducted here along with how drastic the vegetation coverage changes post-fire.

It has been an exciting and busy first field season here at the Jones Center. This summer I plan to start analyzing the data. During my next field season, I am planning to expand to other species besides rabbits including small mammal.

A female Eastern Cottontail that was released after capture. You can see the ear tag and VHF collar to track her.

Two Eastern Cottontails caught in Tomahawk traps.

GRANTS, AWARDS, AND ACHIEVEMENTS

Staci Amburgey and *Courtney Davis* received the Frank A. Andersen travel award

David Muñoz received an honorable mention for the Frank A. Andersen travel award

Jason Kaye, professor of soil biogeochemistry, is the recipient of the Penn State College of Agricultural Sciences' 2017 Alex and Jessie C. Black Award for Excellence in Research.

2018-2020 grant. Location, location, location: developing tools for selection and management of landscapes to promote healthy bee populations. Foundation for Food and Agriculture Research. PI *Grozinger* (coPIs: *Hines, Lopez-Uribe, Miller, Patch* (PSU); Douglas (Dickinson); Cariveau, Lonsdorf (U Minnesota), Williams, Nino, Ward (UC Davis)). $1,177,137

2018-2020 grant. Context is key: tools for adapting beekeeping practices to diverse landscapes. USDA-NIFA-AFRI. PI *Grozinger* (coPIs: Douglas (Dickinson), Lonsdorf (U Minnesota), *Miller* (PSU), Patch (PSU)). $901,176

2018-2020 grant. Strengthening urban apiculture, crop production, and biodiversity by understanding the habitat needs of wild and managed bees. USDA-AFRI-ELI Postdoctoral Fellowship. PI: Sponsler; Co-Mentors *Grozinger* and Lonsdorf. $163,230

Melanie Kammerer Allen recently received a USDA NIFA pre-doctoral fellowship ($95,000) for her project, "Designing farms that support wild bees."

In March 2019, *Dr. Laura Russo* will be an Assistant Professor (tenure track) in the Entomology and Plant Pathology Department at the University of Tennessee in Knoxville

Staci M. Amburgey received the NASA Pennsylvania Space Grant Graduate Research Fellowship for the fall 2018 and spring 2019 semester.

Rachel Rozum received a Graduate Research Award from the Center of Landscape Dynamics in spring 2018.

Chad Thomas Patrick Nihranz received the “Intercollege Graduate Student Outreach Achievement Award” this semester.

Courtney Davis received the Russel D. and Gloria T. Harrar Scholarship through the Department of Ecosystem Science and Management and the College of Agricultural Sciences Competitive Grant

Edward Primka received the 2018 Environmental System Science PI meeting Student Travel Fellowship Award on March 6

Ellen Brandell received an honorable mention for NSF GRFP 2018

Christina Aiello, Spencer Carran and *Megan Schall* successfully defended their Ecology dissertations.

RECENT PUBLICATIONS FROM ECOLOGY FACULTY, POST-DOCS & STUDENTS

Aiello CM, Esque TC, Nussear KN, Emblidge PG, and **Hudson PJ**. Associating sex-biased and seasonal behavior with contact patterns and transmission risk in *Gopherus agassizii*. *Behaviour.* Published online:17 February 2018. doi: 10.1163/1568539X-00003477.

Carlson, B.E. and **Langkilde T.** 2017. Body size variation in aquatic consumers causes pervasive community effects, independent of mean body size. *Ecology and Evolution*, 7: 9978-9990.

Davis, C.L., Teitsworth, E., & **Miller, D.A.W**. 2018. Linking multiple data sources to inform inference on spotted salamander population abundance. *Journal of Herpetology*, 52(2), 116–126.

Finney, D.M., J.S. Buyer, and **J.P. Kaye**. 2017. Living cover crops have immediate impacts on soil microbial community structure and function. *Journal of Soil and Water Conservation*. July/August 2017 vol. 72 no 4 361-373. doi: 10.2489/jswc.72.4.361

Finney, D.M. and **J.P. Kaye**. 2017. Functional diversity in cover crop polycultures increases multifunctionality of an agricultural system. *Journal of Applied Ecology*, 54:509-517. doi: 10.1111/1365-2664.12765

Finney, D., E. Murrell, C. White, B. Baraibar, M. Barbercheck, B. Bradley, S. Cornelisse, **M. Hunter**, **J. Kaye**, **D. Mortensen**, C. Mullen, and M. Schipanski. 2017. Ecosystem services and disservices are bundled in simple and diverse cover cropping systems. *Agricultural and Environmental Letters*. doi: 10.2134/ael2017.09.0033

Fonnesbeck, C.J., **Shea, K., Carran, S.**, de Moraes, J.C., Gregory, C.J., Goodson, J.L. and **Ferrari. M.J.** (accepted 15 Feb 2018). Measles outbreak response decision-making under uncertainty: A retrospective analysis. *Journal of the Royal Society Interface.*

Hoagland, B., T.A. Russo, X. Gu, **L. Hill**, **J. Kaye**, B. Forsythe, and S. L. Brantley. 2017. Hyporheic zone influences on concentration-discharge relationships in a headwater sandstone stream. *Water Resour. Res*, 53: 4643–4667. doi: 10.1002/2016WR019717.

Holt, H.L., Villar, G. and **C.M. Grozinger**. Molecular, physiological and behavioral responses of honey bee (*Apis mellifera*) drones to infection with microsporidian parasites. *Journal of Invertebrate Pathology* (accepted).

Inamine, H., Ellner, S.P., Newell, P.D., Luo, Y., Buchon, N., Douglas, A.E. 2018. Spatiotemporally Heterogeneous Population Dynamics of Gut Bacteria Inferred from Fecal Time Series Data. *American Society for Microbiology,* 9:1.

Kaye, J.P., and M. Quemada. 2017. Using cover crops to mitigate and adapt to climate change: A review. *Agronomy for Sustainable Development*, 37:4. DOI 10.1007/s13593-016-0410-x

Levin, S., Galbraith, D., Sela, N., Erez, T., **Grozinger, C.M.**, and N. Chejanovsky. 2017. Presence of Apis rhabdovirus-1 in populations of pollinators and their parasites from two continents. *Frontiers in Microbiology*.

Ma, R., Villar, G., **Grozinger, C.M.**, and J. Rangel. Larval pheromones act as colony-wide regulators of collective foraging behavior in honey bees. *Behavioral Ecology* (accepted).

MacLeod, K.J., Krebs, C.J., Boonstra, R., Sheriff, M.J. 2017. Fear and lethality in snowshoe hares: the deadly effects of non-consumptive predation risk. *Oikos*, 127 (3): 375-380.

Miller, D.A.W., Campbell Grant, E. H., Muths, E., **Amburgey, S. M.,** Adams., M. J., Joseph, M. B., Waddle, J. H., Johnson, P. T. J., Ryan, M. E., Schmidt, B. R., Calhoun, D. L., **Davis. C. L.** et al. Quantifying Climate Sensitivity and Climate Driven Change in North American Amphibian Communities. *Nature Communications* (Paper Accepted).

Mu, J., Wu, Q., Yang, Y., Huang, M. and **C. M. Grozinger.** Plant reproductive strategies vary under low and high pollinator densities. *Oikos.* 10.1111/oik.04711 (in press).

Mina O., Gall H.E., Elliott H.A., Watson J.E., Mashtare M.L., **Langkilde T.,** Harper J.P., and **Boyer E.W.** 2018. Estrogen occurrence and persistence in vernal pools impacted by wastewater irrigation practices. *Agriculture, Ecosystems and Environment*, 257: 103-112.

Owen D.A.S., Robbins T.R. and **Langkilde T.** 2017. Trans-generational but not early-life exposure to stressors influences offspring morphology and survival. *Oecologia*, 186: 347-355.

Rosenzweig, S.T., **M.E. Schipanski**, and **J.P. Kaye**. 2017. Rhizosphere priming and plant-mediated cover crop decomposition. *Plant and Soil*, 417: 127-139. https://doi.org/10.1007/s11104-017/

Russo, L. Miller, A.D. Tooker, J., Bjornstad, O.N., and Shea, K. 2018. Quantitative evolutionary patterns in bipartite networks: Vicariance, phylogenetic tracking, or diffuse coevolution? *Methods in Ecology and Evolution*, 9:761-772.

Schipanski, M., M.E. Barbercheck, E.G. Murrell, J. Harper, **D.M. Finney**, **J.P. Kaye**, R.E. Smith, and **D.A. Mortensen**. 2017. Balancing multiple objectives in organic feed and forage cropping systems. *Agriculture, Ecosystems &Environment,* 239:219-227.

RECENT PUBLICATIONS FROM ECOLOGY FACULTY, POST-DOCS & STUDENTS

Sheriff, M.J., Bell, A., Boonstra, R., Dantzer, B., Lavergne, S., McGhee, K.E., **MacLeod, K.J.,** Winandy, L., Zimmer, C., and O. P. Love. 2018. Integrating ecological and evolutionary context in the study of maternal stress. *Integrative and Comparative Biology*, 57 (3): 437-449.

Sparkman, A.M., Chism, K., Bronikowski, A., Brummett, L., Combrink, L., **Davis, C.L.**, Holden, K., Kabey, N., & **Miller, D.A.W**. 2018. Differences in developmental phenology and maternal egg provisioning in two sympatric viviparous snakes. *Ecology and Evolution,* 8(6), 3330–3340.

Tylan C. and **Langkilde T.** 2017. Local and systemic immune responses to different types of phytohemagglutinin in the green anole: Lessons for field ecoimmunologists. *Journal of Experimental Zoology,* 327: 322-332.

A year in the life of an interseeded cover crop. Top Left - Bottom Right: May thru April. Photo Credit: Sarah Isbell