Living in the Phantom Gas Field: Physiological Responses of Sagebrush to Human Noise-Induced Changes in Arthropod Herbivory

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Background

Birds and bats provide essential ecosystem services such as predation on plant-damaging herbivorous insects.

Increases in human noise-disturbance alter avian predator activity, creating the potential for "top-down" alterations in ecosystem services across multiple trophic levels (birds/bats→insects→plants→soil).

The impacts of altered soundscapes from human noise has not been thoroughly investigated across multiple trophic levels, nor have the mechanisms underlying these ecosystem-scale changes.

Our study is one of the first to examine the effects of noise pollution across multiple trophic levels, using an experimental approach.

We broadcasted recordings of natural-gas-well compressor-station noise, and investigated how this noise resulted in changes in shrub herbivory, growth, and physiology, presumably because of noise-induced reductions in bird and bat predation on herbivorous insects.

Research Questions

- Will shrubs growing at study sites exposed to chronic human noise experience an increase in arthropod-herbivory, compared to shrubs growing in control ("quiet") areas?
- Are there differences between photosynthetic CO_2 assimilation, chlorophyll fluorescence (photosystem II efficiency), and water stress among control (noise-off) and treatment (noise-on) shrubs?

Methods

Study Site: National Birds of Prey Conservation Area, SW of Boise, ID.

12 sites: 6 treatment sites broadcasting recordings 24hrs/day; and 6 control sites with no broadcast noise.

Each site was located >0.5 Km away from any road to exclude potential vehicle disturbances and/or noise biases

A total of 72 shrubs (*A. tridentata*) were measured monthly for:

Herbivory-- stem growth, number of leaves, and herbivory damage (bite marks and total leaf damage).

Gas Exchange—photosynthesis, respiration, transpiration, and stomatal conductance were measured using a LiCOR LI-6400 portable photosynthesis machine

Water Status—pre-dawn water potentials were measured using a portable pressure chamber (PMS Instruments, Model PMS-1000).

Leaf Chlorophyll Fluorescence—photochemical efficiency was measured using a Walz Mini-Pam Photosynthesis Yield Analyzer.

Results

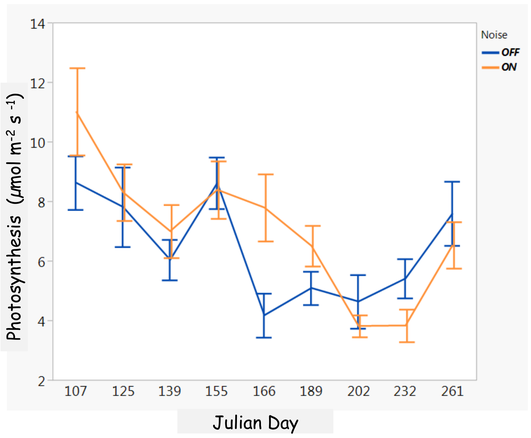


Fig. 1. Variation in photosynthesis from April through September 2015. Points are means ±SE. Noise did not have a strong effect on photosynthesis throughout the summer, however, there appears to be greater photosynthesis in noise-on shrubs during the summer months than in control shrubs. Preliminary data suggests that herbivory on treatment shrubs was 2x greater than at control shrubs.

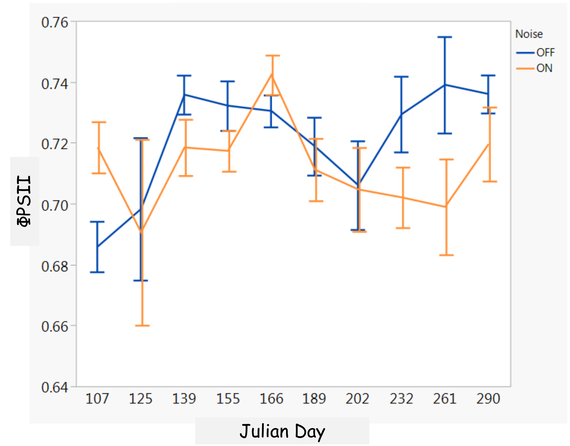


Fig. 2. Variation in photochemical efficiency ("ΦPSII") from April through October 2015. Points are means ±SE. Noise had a marginal effect on photosystem efficiency throughout the summer. Preliminary data suggests that herbivory on treatment shrubs was 2x greater than at control shrubs.

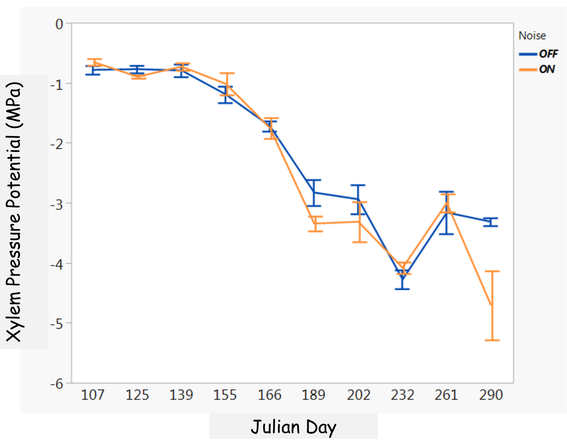
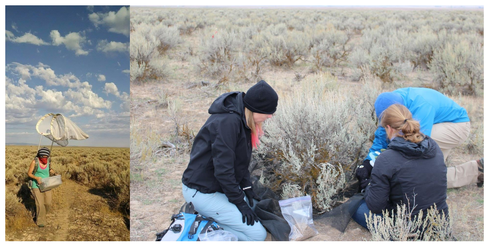


Fig. 3. Variation in pre-dawn water potentials from April through October 2015. Points are means ± SE. Noise did not have a strong effect on pressure potentials of shrubs throughout the year, however, there were occasionally significant differences later in the summer.

Discussion

- During the late-summer months, when water was more limiting, **experimental noise had some effect on shrubs**, with less significant effects at other times during the growing season.
  →*Photosynthesis* was greater in shrubs at noise-on sites during mid-summer, but lower in shrubs at noise-on sites towards the end of the growing season.
  →*Photochemical efficiency* was frequently less in shrubs at noise-on sites, especially at the end of the growing season.
  →*Water potentials* in shrubs at noise-on sites were occasionally more negative, especially later in summer
- Taken collectively, our preliminary evidence suggests that **human noise may affect shrub herbivory and physiology**, with potential cascading influences at ecosystem scales. Further analysis underway to determine the statistical and biological significance of our findings.



Ongoing Research

- Processing of vegetative and floral samples for ^{13}C and ^{15}N isotope ratios, to determine if there were any changes in isotopic discrimination because of herbivory and/or noise directly.
- Analyses of the amount of herbivory damage between our control and treatment sites
- Analysis of shrub reproductive success, through floral stem production and seed number and quality.
- Regression analysis and AIC model building to incorporate findings from other members of our research team (including bird and bat populations, insect abundances, leaf litter fall analysis, and shrub defense-compound analyses)

Acknowledgments

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