Title: Assessing the demographic response of an early seral songbird to intensive forest management

Investigators:
Dr. Matthew G. Betts (CoF, OSU), Dr. James W. Rivers (CoF, OSU)

Project duration:
Our group initiated a two-year (2013-2014) landscape-scale manipulative experiment to assess how IFM impacts songbirds that require early seral forests. Funding from FWHMF funding was obtained to expand this work by supporting field operations scheduled for the 2015 field season (May-August).

Study objectives:
1. Determine whether the intensity of herbicide application is linked to songbird nesting success.
2. Quantify juvenile survival during the critical period immediately after young fledge from the nest.
3. Assess survival of adults that depend on early seral habitats to raise their young.

Summary of accomplishments over past year:
Good progress continued to made on the avian demography study over the last year. As discussed in past progress reports, we did not conduct field work in 2015 but instead undertook detailed data analysis on data collected during the 2013 and 2014 field seasons (>760 sparrow nests located, 70 fledglings radio-tagged). That work has uncovered several important results regarding how herbicides impact songbird demography. Against our initial predictions, we detected no difference in the daily survival rate of nests located across our gradient of experimental herbicide application ($X2 = 3.56$, $P = 0.313$) although daily survival rate was notably lower in the second year of study for all treatments 2014 ($X2 = 12.83$, $P < 0.001$), with no treatment × year interaction ($X2 = 0.38$, $P = 0.944$; Fig. 1A). When examining the number of fledglings produced ha-1 we detected a treatment × year effect on area-specific reproductive output ($F3,8 = 14.69$, $P = 0.001$), but no effect of treatment ($F3,9 = 0.49$, $P = 0.695$) or year ($F1,3= 0.14$, $P = 0.732$; Fig. 1B). For the two least intensive treatments (control, light) area-specific productivity decreased from 2013 to 2014, whereas the opposite pattern was found for the two most intensive treatments (moderate, intensive; Fig. 1B). This result reflects the "green-up" hypothesis, which posits that any negative effects of herbicide on songbird reproduction in the early stages of succession becomes dampened in later years once vegetation emerges in stands on which herbicides are applied more intensively.

In addition to nest survival, we also evaluated post-fledging survival of juvenile sparrows (n=70) from nests located in stands subjected to no-spray control and moderate herbicide treatments. Using Cox-proportional hazards modeling we found no evidence for a difference between post-fledging survival between the two treatments (ß = 0.48 [95% CI: -0.18, 1.14], hazard ratio = 1.62 [95% CI: 0.84, 3.13], $X2 = 2.04$, $P = 0.154$) or year of study (ß = -0.47 [95% CI: -1.15, 0.21], hazard ratio = 0.62 [95% CI: 0.31, 1.24], $X2 = 1.84$, $P = 0.175$). However, we did detect a positive effect of the date of tag deployment on survival (ß = 0.19 [95% CI: 0.10, 0.27], hazard ratio = 1.20 [95% CI: 1.12, 1.32], $X2 = 20.49$, $P < 0.001$). Our results indicate that fledglings raised in unsprayed stands survived approximately half as long as those in stands subjected to current-day herbicide application practices. One hypothesis for this pattern is that the greater vegetative cover on unsprayed stands may have provided more hiding cover for predators of fledglings (e.g., snakes, small mammals) that are themselves preyed upon by higher-order predators (e.g., raptors).

Problems, barriers, proposed changes to objectives:

Observations made during summer 2014 indicated that the expected post-herbicide vegetation response had not advanced at the rate initially expected for all treatments. Because of this, we shifted our investigation of this response so that field work was to be conducted during the 2016 breeding season (May-August). However, observations made during both the 2015 and 2016 summers indicated that the density of White-crowned Sparrows was markedly reduced on stands subjected to no-spray control and light herbicide application treatments, making it impossible to obtain adequate nesting data for testing effects across the full suite of experimental treatments. This was due to rapid vegetation succession on control and light herbicide treatment stands during our study that reduced the amount of bare ground required by sparrows for foraging. Assessment of bird point data collected during 2015-2016 indicated that those declines continued, preventing us from collecting additional demographic data for this study and instead focusing on changes to the community level via point-count data via a related investigation.

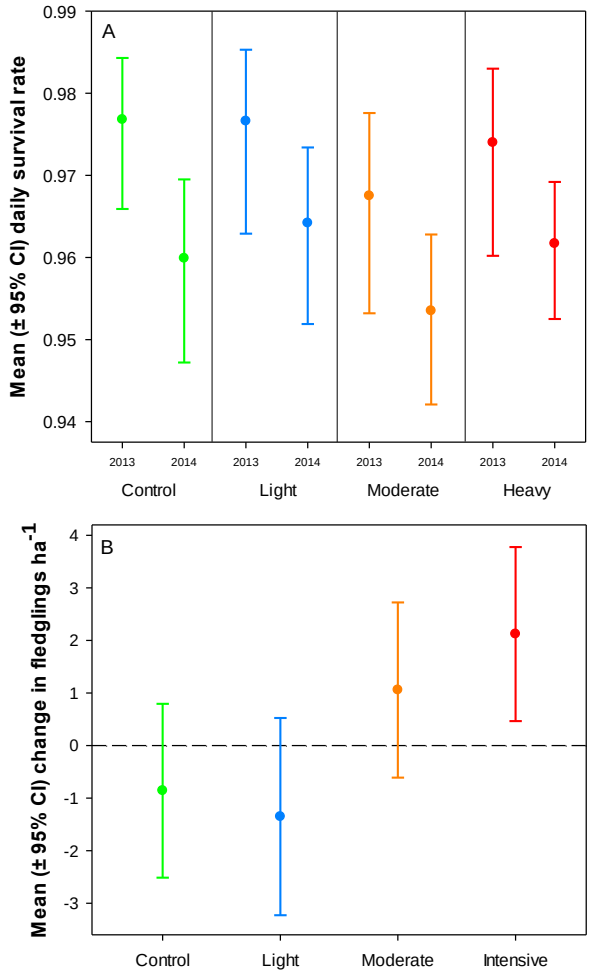

Fig. 1 | Results of a manipulative experiment testing the impacts of herbicide treatments on songbird demographic rates. (A). Nest daily survival rate did not differ between experimental treatments, but was significantly lower in 2014. **(B).** There was a reduction in the number of fledglings produced ha^{-1} between years for nests on no-spray control and light herbicide treatment stands, whereas an increase was found for moderate and intensive herbicide treatment stands, indicating recovery from initially low levels due to management intensity. Point estimates in **(B)** are differences between years (2014 – 2013); dashed line = no difference between years.

Planned work:

Given the large and extensive dataset we have collected and the clear change in response to herbicide treatments we have already detected (Fig. 1B), we decided that adequate data had been obtained for rigorously testing our hypotheses about the impact of herbicides on demographic rates. Therefore, over the past year we have finalized data analysis and manuscript writing for the focal work in this project, and a manuscript form this effort is currently under peer review. However, we have expanded our initial project goals to evaluate how herbicide application intensity influences sex ratio of sparrow offspring through a collaboration with Dr. Brent Horton at Millersville University, Millersville, PA. Dr. Horton and his student, Jennifer Houtz. Molecular sexing for >1000 sparrow nestlings was undertaken during summer 2016 and we are in the process of writing up those results into a manuscript, with submission to Conservation Physiology targeted for early 2017.

Comprehensive summary of project results and impacts over life of project:
Results from our study have already provide new and valuable information about the demographic response of songbirds to intensive forest management practices. Against initial predictions, we have shown that key demographic rates (i.e., nest success, post-fledging survival) of a declining early-successional forest bird was not influenced by the degree of herbicide application on intensively managed stands. Moreover, we found an unexpected interaction between herbicide treatment and time since harvest, indicating that early-successional forest habitats are much more dynamic that previous work has indicated. Our research has also demonstrated that a key characteristic that relates to population structure, namely offspring sex ratio, is not influenced by the degree of herbicide application intensity. Finally, additional work being leveraged from this project is current assessing how the physiological health of adults and offspring are influenced by herbicide application intensity; thus, we expect to produce at least 3 peer-reviewed publications from this project. In addition to sharing this information via peer-reviewed scientific journals, we regularly provide presentations and outreach events for biologists, managers, and other members of the forest industry community so that our results have the broadest impacts as possible. As such, we expect that the impact of our work will extend well into the future and be used by resource managers whose goals are to balance timber production with the conservation of biological diversity.

List of names and brief overview of young professionals engaged with project:
Kristin Jones (Department Forest Ecosystems and Society, Oregon State University) was involved with the project as a graduate student and successfully defended her M.S. thesis in December 2016, which investigated the interactive effects of intensive forest management and temperature on offspring production in the House Wren. She has submitted one of her thesis chapters for publication to a peer-refereed journal (Forest Ecology and Management), and we expect a second manuscript to submitted to a second journal in the near future (Canadian Journal of Forest Research).

Jonah Powell (Department of Fisheries and Wildlife Science, Oregon State University) was involved with the project as an undergraduate student and collected towards an independent study assessing how food provisioning of the House Wren was influenced by the intensity of forest management practices.

Jennifer Houtz (Department of Biology, Millersville University) became involved with the project as an undergraduate honors student during summer 2016. She undertook laboratory work to evaluate how forest herbicide application intensity was linked to offspring sex ratio for nests used in the course of this study. She has already given two presentations on this research to date, including an international ornithological conference, and we anticipate submitting the results from this work to a peer-refereed journal in early 2017.

During summer 2014, 10 enrolled and recent graduates from colleges and universities across the United States were hired to undertaken field data collection for project objectives. Additionally, 17 undergraduate students from Oregon State University obtained research experience on the project by collecting House Wren adult provisioning data from videos during eh 2014-2015 academic year.

List of presentations, posters:
Rivers, J. W. 2016. Evaluating the effects of intensive forest management on songbird productivity. Invited oral presentation and panel discussion at the annual meeting of the Oregon Forest and Industries Council, Sun River, OR.

Rivers, J. W. 2016. Testing the impact of experimental herbicide treatments on breeding productivity of early-successional forest songbirds. Invited oral presentation at the annual meeting of the Pacific Northwest Reforestation Council, Vancouver, WA.

Houtz, J. L., J. W. Rivers, B. M. Horton, and M. G. Betts. 2016. Evaluating the influence of forest herbicides on offspring sex ratio in an early-successional forest songbird. Poster presentation at the 6th North American Ornithological Conference, Washington, D.C.

Houtz, J. L., J. W. Rivers, J. W., B. M. Horton, and M. G. Betts. 2016. Poster presentation at the annual Pennsylvania State System of Higher Education Undergraduate Research Conference in Science, Technology, Engineering, and Mathematics, Millersville, PA.

Jones, K. N., J. W. Rivers, and M. G. Betts. 2015. Effects of intensive forest management on reproductive success in a cavity-nesting songbird. Oral presentation for the Bird Nerds Student Club, Corvallis, Oregon.

Jones, K. N., J. W. Rivers, and M. G. Betts. 2015. Effects of intensive forest management on reproductive success in a cavity-nesting songbird. Oral presentation at the first annual Willamette Valley Bird Symposium, Corvallis, Oregon.

Rivers, J. W., M. G. Betts, A. J. Kroll, C. J. Schwarz, and J. Verschuyl. 2015. Songbird demographic response to herbicide application in early-seral forest. Oral presentation at the 133rd meeting of the American Ornithologists' Union, Norman, OK.

Rivers, J. W., J. Verschuyl, A. J. Kroll, and M. G. Betts. 2015. The influence of intensive forest management practices on breeding success of the White-crowned Sparrow, an early-seral songbird. Oral presentation at the Oregon Chapter of The Wildlife Society, Eugene, OR.

Rivers, J. W., J. Verschuyl, A. J. Kroll, and M. G. Betts. 2015. Influence of intensive forest management on the breeding success of an early-seral songbird. Oral presentation at the Washington Chapter of The Wildlife Society, Grand Mound, WA.

Rivers, J. W., J. Verschuyl, A. J. Kroll, and M. G. Betts. 2015. Quantifying tradeoffs between biodiversity and timber production in western Oregon. Oral presentation at the Washington Chapter of The Wildlife Society, Grand Mound, WA.

Betts, M. G. 2014. Introduction to the Intensive Management Study. Invited oral presentation at the Wildlife in Managed Forests: Songbirds and Early Seral Habitats Symposium, Oregon Forest Resources Institute, Albany, Oregon.

Betts, M. G. 2014. Are changes in bird abundance likely to influence insect abundance and herbivory on trees? Invited oral presentation at the Wildlife in Managed Forests: Songbirds and Early Seral Habitats Symposium, Oregon Forest Resources Institute, Albany, Oregon.

Jones, K. N., J. W. Rivers, and M. G. Betts. 2014. Investigating the effects of intensive forest management on reproductive success in a cavity-nesting songbird: preliminary results and future directions. Seminar given to the Oregon State University AVES group, Corvallis, OR.

Jones, K. N., J. W. Rivers, and M. G. Betts. 2014. Effects of intensive forest management on reproductive success in a cavity-nesting songbird. Poster presentation at the 132nd meeting of the American Ornithologists' Union, Estes Park, Colorado.

Rivers, J. W. 2014. Songbird demography in early seral habitats. Invited oral presentation at the Wildlife in Managed Forests: Songbirds and Early Seral Habitats Symposium, Oregon Forest Resources Institute, Albany, Oregon.

Rivers, J. W., J Verschuyl, A. J. Kroll, and M. G. Betts. 2014. Quantifying the demographic consequences of intensive management practices on breeding birds in early seral plantation forests. Invited oral presentation at the 2014 Annual Meeting of the Oregon Chapter of The Wildlife Society, Bend, OR.

Rivers, J. W., and M. G. Betts. 2014. Intensive forest management practices reduce nest survival and offspring production: evidence from a landscape-scale experiment. Oral presentation at the 132nd meeting of the American Ornithologists' Union, Estes Park, Colorado.

Verschuyl, J., A. J. Kroll, J. W. Rivers, K. Jones, and M. G. Betts. 2014. A manipulative study of the effects of forest herbicide use on nest success of early seral birds. Oral presentation at the 2014 Annual Meeting of the Washington Chapter of The Wildlife Society, Pasco, WA.

List of publications, thesis citations

Rivers, J. W., M. G. Betts, A. J. Kroll, C. J. Schwarz, and J. Verschuyl. In review. Dynamic response in breeding productivity to experimental herbicide treatments by an early-successional forest songbird.

Jones, K. N., J. W. Rivers, and M. G. Betts. In review. Intensive forest management practices exert weak and variable effects on microclimate in early-seral forest.

Rivers, J. W., J. L. Houtz, B. M. Horton, and M. G. Betts. High-throughput molecular sexing finds no link between forest herbicides and offspring sex ratio in a migratory songbird. Anticipated for submission to Conservation Physiology.

Jones, K. N., M. G. Betts, and J. W. Rivers. Intensive forest management and local microclimate exert negligible effects on reproductive success in a cavity-nesting songbird. Anticipated for submission to Canadian Journal of Forest Research.

Jones, K. N. 2015. Effects of intensive forest management on air temperature and reproductive success in a cavity-nesting songbird. M.S. thesis, Department of Forest Ecosystems and Society, Oregon State University. December 2015.