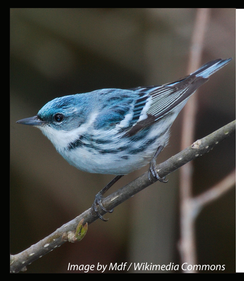
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Modeling Habitat Degradation of the Cerulean Warbler Using GIS: Ash Tree Decline & Hydraulic Fracturing

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Introduction

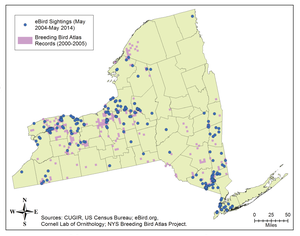
Ornithologists have recently become concerned over the rapidly decreasing habitat of the cerulean warbler (*Dendroica cerulea*), a songbird whose range includes the forests of New York State. The species, already dwindling in number, faces two specific ecological and industrial challenges in the NY region. Across the American Midwest and Northeast, ash trees, commonly found within the warbler's habitat [1], have been killed or preemptively exterminated due to the presence of the invasive emerald ash borer beetle (EAB), resulting in deforestation. In addition, high-volume hydraulic fracturing (hydrofracking) is not currently permitted by the NY Department of Environmental Conservation (DEC), but natural gas companies are acquiring leases in anticipation of policy changes.

Research Question

How might the habitat of the cerulean warbler be fragmented if (a) EAB continues to spread infectiously and (b) hydrofracking is legalized and new well pads are developed?

Methods

Sample & Measures



* Cerulean warbler presence data was used to test the accuracy of our constructed habitat. Data included citizen sightings of the bird in NY from May 2004-May 2014 (eBird.org) as well as tracts where the bird's presence is probable/confirmed (Cornell's Breeding Bird Survey, 2000-2005).
* State-wide environmental features (i.e. land cover type, elevation, water bodies) from the USGS and the NYS DEC were mapped and used to include or eliminate areas from our habitat model.
* Geographic points representing EAB-infected ash trees (between 2009-2014) were obtained from the NYS DEC. Each point was treated as a possible source from which EAB could continue to spread.
* Ash tree prevalence was measured by the basal area (trunk cross-sectional area) of black, green, and white ash species per 30 x 30m pixel.

Acknowledgments

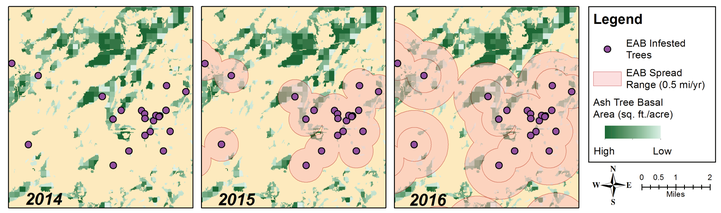
I'd like to recognize Kim Diver for her feedback and guidance throughout my work; Jason Simms for assisting with plenty of technical difficulties; Eric Stephen for inspiring me to succeed in this program despite its quick learning curve; Katie Lindeman, Arthur Halliday, and Lydia Tierney for keeping me sane; and especially Manolis Kaparakis, for being astoundingly encouraging and instructive.

Methods cont'd

* Records of well permit applications were pulled from the NY Division of Mineral Resources Oil and Gas database (current as of 6/9/2014). We retained entries for horizontally-oriented wells drawing from the Marcellus or Utica shale formations; these points were treated as sites of interest to natural gas companies for further development. 93 boreholes on 52 pad sites in 8 counties were retained.

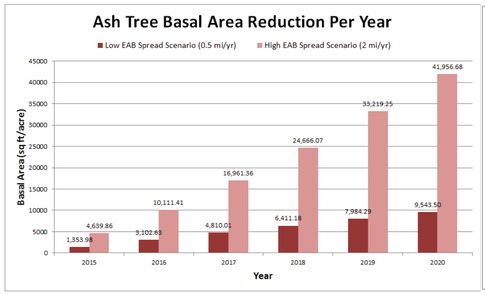
Analysis

* **Habitat Creation:** Based upon our literature review, our final habitat (6,960,330.55 acres) included land cover types (1) woody wetland, (2) emergent herbaceous woodlands, and (3) deciduous forest with a slope of < 3° and within 250m of water.
* **Modeling EAB Spread:** Buffer rings were created around infected trees at distances of ½ mi and 2 mi, representing the minimum and maximum natural spread of EAB per year for 6 years. Ash tree basal area (BA) per pixel within the buffer was reduced by 5% each year to represent tree die-back. A pixel was determined unsuitable habitat when its total tree BA reached <50% of its original BA.



* **Modeling Gas Well Development:** Hypothetical well pads were generated in potential development areas to be 3.5 acres square with the well borehole(s) at the center. A 30-ft wide access road was generated for each pad based on the shortest distance to the nearest road. We then intersected the developed pads/roads with our habitat layer, erasing areas of the model overlapped by the developed patches.

Results



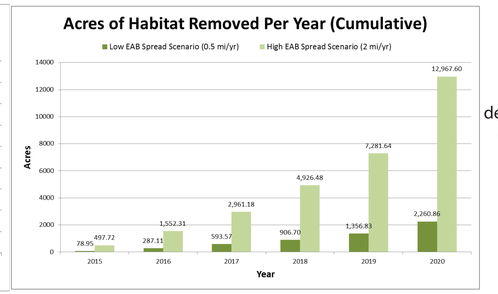
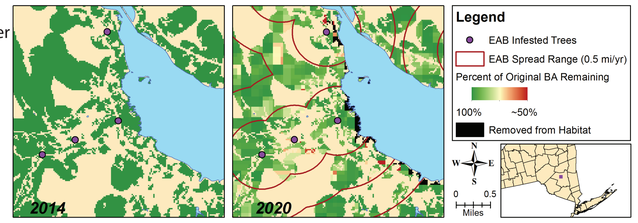


Figure One: Cumulative amount of ash tree BA removed per year, and the number of habitat acres deemed unsuitable (deforested >50% from starting total BA value) since the start of the scenario. The maximum death scenario, removing 12,967.60 acres, disturbs 0.00186% of the bird's total habitat statewide.

Figure Three: The forested state of warbler habitat before and after the low-spread EAB scenario (year 2020) near the Ashokan Reservoir in Ulster County. Percentages represent the percent of original forest BA that remains after 6 years of ash tree die-off. Much of the habitat loss occurred in areas already low in total BA, like what is pictured here.



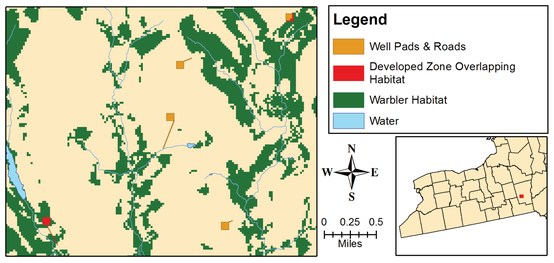


Figure Four: Five well pads and their access roads in Chenango County. The red areas shown in this image amount to about 5.12 acres of cleared habitat. (Residential streets and parcel boundaries not shown).

County Name	# of Boreholes	# of Wellpads	Acres of Habitat Removed
Broome	20	10	407.46
Cattaraugus	1	1	0.00
Chemung	12	5	68.72
Chenango	22	22	15,150.68
Delaware	25	6	2,711.90
Madison	2	2	116.74
Steuben	1	1	0.00
Tioga	10	5	131.59
TOTAL	**93**	**52**	**18,587.09**

Figure Five: Summary of well locations and land use for the 8 counties containing potential leases. Some "multi-well" pads leased by the same company contained up to 6 individual boreholes. The total acreage removed by the pads (18,587.09) equals 0.00267% of the bird's total habitat statewide.

Discussion

* The two mechanisms studied deplete habitat in different ways. EAB attacks one tree at a time, and unless a forest stand is highly ash-dense there are often plenty remaining host trees in which the warbler is able to nest.
* While the ash decline rates our scenarios model are plausible, the criteria used to define inhospitable habitat (>50% deforested) does not seem to reflect real-world ecological observations of how warblers select their habitat.
* Alternatively, well pad development clears land uniformly and in large amounts. Although gas companies remediate the land after the initial drilling phase [2], vegetation could take years to regrow to a state that warblers find hospitable.
* However, our erased habitat estimates may be high due to the randomization of our well pad creation. In reality, gas companies select pad locations on a very case-by-case basis, avoiding factors like high surface slopes and pre-existing forest [3].

Conclusions & Implications

Our habitat reduction models suggest that hydrofracking development poses the bigger threat to the warbler's habitat both in terms of acreage lost and speed of the loss (land clearing would take weeks/months versus years). However, this outcome must be tempered by the fact that each analysis removes no more than <0.0027% of the total habitat in the state. These models appear most useful on the small-scale, microhabitat level.

To improve upon the accuracy of these models, future studies could incorporate the nuanced variables behind well pad location selection to be more industry-realistic. Including tree canopy height data as a criteria for ideal habitat, as well as a variable for nearby suitable habitat in the ash reduction model, may provide results that more closely mimic the warbler's behavior, as tree height has been shown to play a more important role than tree density or species in nesting site selection [4].

References

[1] Rosenberg, Kenneth V., Sara E. Barker, and Ronald W. Rohrbaugh. "An atlas of Cerulean Warbler populations." Cornell Laboratory of Ornithology, Ithaca, New York, New York, USA (2000).

[2], [3] New York State Department of Environmental Conservation. *Revised Draft SGEIS Chapter 5: Natural Gas Development Activities & High–Volume Hydraulic Fracturing.* New York State Department of Conservation. New York State Department of Conservation, Sept. 2011. Web.

[4] Hamel, Paul B. 2000. Cerulean Warbler Status Assessment. U.S. Fish and Wildlife Service, April 2000