Leaf long and prosper? Shedding light on invasive shrubs in eastern deciduous forests

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Leaf long and prosper?
Shedding light on invasive shrubs in eastern deciduous forests

Dr. Margot Kaye
Associate Professor of Forest Ecology
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Dr. Eric Burkhart
Plant Science Program Director
Shaver's Creek
Non-native, invasive shrubs

- **Ligustrum spp.** border privet
- **Euonymus alatus** burning bush
- **Lonicera maackii** Amur honeysuckle
- **Lonicera morrowii** bush honeysuckles
- **Berberis thunbergii** Japanese barberry
Shedding light on invasive shrubs in eastern deciduous forests of North America

Why do we care about invasive shrubs?

Do invasive shrubs have extended leaf phenology across the range? (Leaf long?)

What are some impacts of novel leaf phenology?

Is there an advantage to novel leaf phenology? (Leaf long and prosper?)
Shedding light on invasive shrubs in eastern deciduous forests of North America

Why do we care about invasive shrubs?

Do invasive shrubs have extended leaf phenology across the range?

What are some impacts of novel leaf phenology?

Is there an advantage to novel leaf phenology?

Invasive shrub removal benefits native plants in an eastern deciduous forest of North America

Erynn Maynard-Bean¹ and Margot Kaye²

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Abstract

In eastern deciduous forests of North America, invasive shrubs are increasing in richness and abundance at the expense of native species across taxa. Invasive shrubs create an understory that is more dense than both recent and historical preinvasion conditions. Interest in invasive shrub removal to restore native habitat is growing, but our understanding of natural regeneration following treatment of a diverse invasive shrub community is lagging. Using an invasive shrub removal experiment, we provide insight into the effect of repeated removal of a suite of 18 invasive shrub species dominated by border privet (Ligustrum obtusifolium Siebold & Zucc.). In 2009, invasive shrubs were removed from five 20-m-diameter treatment plots, each with a paired control plot. Seven years later, we find an increase in plant diversity, native understory species abundance, and overstory tree species regeneration for individuals under a meter in height. For plants 1 to 4 in height, the removal treatment has a positive effect on understory woody species, but there has been no change in regenerating overstory trees. A lack of overstory tree regeneration to greater heights is not surprising, given the time frame and the closed-canopy conditions. However, other factors, such as white-tailed deer
Initiated 2009
20 m diameter
18 species removed
Initiated 2009
20 m diameter
Sampled in 2016
Response of the native community to removal

Estimate of invasive shrub impacts
The removal treatment increased native shrubs

<table>
<thead>
<tr>
<th>Relative effect of removal treatment (%)</th>
<th>(T-C)/mean(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-400 -200 0 200 400 600 800</td>
<td></td>
</tr>
<tr>
<td>native shrub count, &lt; 1 m</td>
<td></td>
</tr>
<tr>
<td>native shrub count, 1 - 4 m</td>
<td></td>
</tr>
<tr>
<td>native tree count, &lt; 1 m</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>invasive herb cover</td>
<td></td>
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<td>native herb cover</td>
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The removal treatment increased canopy tree regeneration

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The removal treatment increased native herbaceous species, but not invasives

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<td>invasive herb cover</td>
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<tr>
<td>native herb cover</td>
<td></td>
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Plant diversity
(Shannon-Wiener index)
30.6% [9.9, 51.3]
How well is the native community responding relative to uninvaded portions of the forest?

Native understory plants:

- Removal treatments: 47.4% cover [32.1, 63.4]
- Unmanaged, uninvaded forest: 17.4% cover [11.9, 24.4]

Why does observational sampling underestimate?
Non-native, invasive shrubs

*Ligustrum* spp.
border privet

*Lonicera maackii*
Amur honeysuckle

*Lonicera morrowii*
bush honeysuckles

*Euonymus alatus*
burning bush

*Berberis thunbergii*
Japanese barberry
Ligustrum obtusifolium, border privet
Lonicera spp, bush honeysuckles
Viburnum dilitatum, linden viburnum

Lonicera morrowii, bush honeysuckle with native Lindera benzoin, spicebush
Does my research matter??

6 invasive, 5 native
Studies quantifying extended leaf phenology

Shedding light on invasive shrubs in eastern deciduous forests of North America

Why do we care about invasive shrubs?

Do invasive shrubs have extended leaf phenology across the range?

What are some impacts of novel leaf phenology?

Is there an advantage to novel leaf phenology?

Shady Invaders
Citizen Science Campaign

USA
National Phenology Network
Taking the Pulse of Our Planet
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Special thanks to Tyler Wagner for statistical training and consultation!
Shady Invaders
Citizen Science Campaign

From 2015 – 2018:
> 8,000 observations,
804 shrubs,
384 sites

Native shrubs
- spicebush (*Lindera benzoin*)
- mapleleaf viburnum (*Viburnum acerifolium*)
- flowering dogwood (*Cornus florida*)
- gray dogwood (*Cornus racemosa*)
- black haw (*Viburnum prunifolium*)
- alternateleaf dogwood (*Cornus alternifolia*)
- southern arrowwood (*Viburnum dentatum*)
- hobble-bush (*Viburnum lantanoides*)

Invasive shrubs
- Japanese barberry (*Berberis thunbergii*)
- Amur honeysuckle (*Lonicera maackii*)
- multiflora rose (*Rosa multiflora*)
- burningbush (*Euonymus alatus*)
- privet (*Ligustrum sp.*)
- Morrow's honeysuckle (*Lonicera morrowii*)
- Tatarian honeysuckle (*Lonicera tatarica*)
Native shrubs:
- spicebush (Lindera benzoin)
- mapleleaf viburnum (Viburnum acerifolium)
- flowering dogwood (Cornus florida)
- gray dogwood (Cornus racemosa)
- black haw (Viburnum prunifolium)
- alternateleaf dogwood (Cornus alternifolia)
- southern arrowwood (Viburnum dentatum)
- hobblebush (Viburnum lantanoides)
- Japanese barberry (Berberis thunbergii)
- Amur honeysuckle (Lonicera maackii)
- multiflora rose (Rosa multiflora)
- burningbush (Euonymus alatus)
- privet (Ligustrum sp.)
- Morrow's honeysuckle (Lonicera morrowii)
- Tatarian honeysuckle (Lonicera tatarica)

Invasive shrubs:
- Leaf emergence
  - 153 sites
  - 911 observations
- Leaf off
  - 72 sites
  - 589 observations
Leaf emergence and leaf off across latitude by nativity

Days earlier:

36.5°N
38.1 days
[25.7, 50.8]

40.5°N
26.6 days
[15.7, 37.8]

46.5°N
9.5 days
[-3.7, 23.0]

Days later:

36.5°N
38.9 days
[17.4, 57.5]

40.5°N
30.3 days
[19.2, 41.2]

46.5°N
17.4 days
[-10.8, 40.1]

Species-specific differences
Leaf emergence across latitude by species

<table>
<thead>
<tr>
<th>Common name</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>alternate leaf dogwood</td>
<td>CoAl</td>
</tr>
<tr>
<td>Amur honeysuckle</td>
<td>LoMa</td>
</tr>
<tr>
<td>blackhaw</td>
<td>ViPr</td>
</tr>
<tr>
<td>burningbush</td>
<td>EuAl</td>
</tr>
<tr>
<td>bush honeysuckle</td>
<td>LoM</td>
</tr>
<tr>
<td>flowering dogwood</td>
<td>CoFl</td>
</tr>
<tr>
<td>gray dogwood</td>
<td>CoR</td>
</tr>
<tr>
<td>hobblebush</td>
<td>ViLa</td>
</tr>
<tr>
<td>Japanese barberry</td>
<td>BeTh</td>
</tr>
<tr>
<td>mapleleaf viburnum</td>
<td>ViAc</td>
</tr>
<tr>
<td>multiflora rose</td>
<td>RoMu</td>
</tr>
<tr>
<td>northern spicebush</td>
<td>LiBe</td>
</tr>
<tr>
<td>privet</td>
<td>LiSpp</td>
</tr>
<tr>
<td>southern arrowwood</td>
<td>ViDe</td>
</tr>
</tbody>
</table>
Leaf emergence and environmental cues

Accumulated warmth, AGDD (Jan - Mar)
Chill days (Dec - Feb)
Accumulated winter precipitation (Dec - Feb)
Leaf emergence and environmental cues

Spring warming (AGDD): forest carbon and productivity and predictions under climate change
Shedding light on invasive shrubs in eastern deciduous forests of North America

Why do we care about invasive shrubs?

Do invasive shrubs have extended leaf phenology across the range?

What are some impacts of novel leaf phenology?

Understory light availability

Is there an advantage to novel leaf phenology?

**Hypothesis:** Invasive shrubs allow less light infiltration than natives, especially in the spring and fall.
Light energy
lumens/m²
200 - 1200 nm
Apr 2014 – Jan 2019

HOBO Pendant 8K
Data Loggers
Difference in light energy below invasive and native shrubs (effect of invasive shrubs on light energy infiltration at 0.5 m)

**Hypothesis:** Invasive shrubs allow less light infiltration than natives, especially in the spring and fall.

<table>
<thead>
<tr>
<th>season</th>
<th>lumens/m²</th>
</tr>
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<tbody>
<tr>
<td>all</td>
<td>-891 [-1,072, -735]</td>
</tr>
<tr>
<td>spring</td>
<td>-1,981 [-2,604, -1,380]</td>
</tr>
<tr>
<td>summer</td>
<td>-1,038 [-1,221, -845]</td>
</tr>
<tr>
<td>fall</td>
<td>-547 [-660, -429]</td>
</tr>
<tr>
<td>winter</td>
<td>-257 [-372, -151]</td>
</tr>
</tbody>
</table>
Light influences:
Seed germination, plant growth and reproduction, ectothermic species behavior and development
Litter decomposition, nutrient cycling, fire behavior
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Seed germination, plant growth and reproduction, ectothermic species behavior and development
Litter decomposition, nutrient cycling, fire behavior

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*Photosynthesize longer*
Photosynthetically active radiation (PAR)

$\mu\text{mol m}^{-2} \text{s}^{-1}$

400 – 700 nm

Mar 2016 – Jan 2019
Seasonal photosynthetically active radiation (PAR) midday

\[ \text{PAR (µmol m}^{-2}\text{s}^{-1}) \]

Calendar date

winter  spring  summer  fall

open, \( R^2 = 0.83 \)

understory, \( R^2 = 0.67 \)
Phenology observations

3 sites

9 species:

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Species code</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>invasive</td>
<td></td>
<td></td>
<td>86</td>
</tr>
<tr>
<td>Japanese barberry</td>
<td>Berberis thunbergii DC.</td>
<td>BeTh</td>
<td>18</td>
</tr>
<tr>
<td>winged burningbush</td>
<td>Euonymus alatus (Thunb.) Siebold</td>
<td>EuAl</td>
<td>18</td>
</tr>
<tr>
<td>common privet</td>
<td>Ligustrum ovalifolium Siebold &amp; Zucc.</td>
<td>LiOb</td>
<td>19</td>
</tr>
<tr>
<td>Amur honeysuckle</td>
<td>Lonicera maackii (Rupr.) Herder</td>
<td>LoMa</td>
<td>18</td>
</tr>
<tr>
<td>Linden viburnum</td>
<td>Viburnum lantanum Thunb.</td>
<td>ViDi</td>
<td>13</td>
</tr>
<tr>
<td>native</td>
<td></td>
<td></td>
<td>69</td>
</tr>
<tr>
<td>bigfruit hawthorn</td>
<td>Crataegus macrophylla Ashe.</td>
<td>CrMa</td>
<td>18</td>
</tr>
<tr>
<td>spicebush</td>
<td>Lindera benzoin L.</td>
<td>LiBe</td>
<td>14</td>
</tr>
<tr>
<td>mapleleaf viburnum</td>
<td>Viburnum acerifolium L.</td>
<td>ViAc</td>
<td>19</td>
</tr>
<tr>
<td>blackhaw</td>
<td>Viburnum prunifolium L.</td>
<td>ViPr</td>
<td>18</td>
</tr>
</tbody>
</table>
Leaf phenology and understory light availability (PAR)

- **Leaf phenology**:
  - Native shrubs: 21 days
  - Invasive shrubs: 26 days

- **Percent of annual potential PAR exposure**:
  - Invasive: 0.7
  - Native: 0.6

- Statistical significance:
  - p < 0.0001
citizen science project

unified framework
Committee:
Margot Kaye, co-adviser
Eric Burkhart, co-adviser
Dave Eisenstat
Dave Mortensen

Field/lab help:
Steve Bean, Nick Hugo,
Teal Jordan, Richard Novak,
Brant Portner, Warren Reed,
Sky Templeton, and
MANY citizen scientists!

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Laura Leites

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Service Assistant, Ecology IGDP
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