Large Wood in Central Appalachian Headwater Streams: Controls on and Potential Changes to Wood Loads from Infestation of Hemlock Woolly Adelgid

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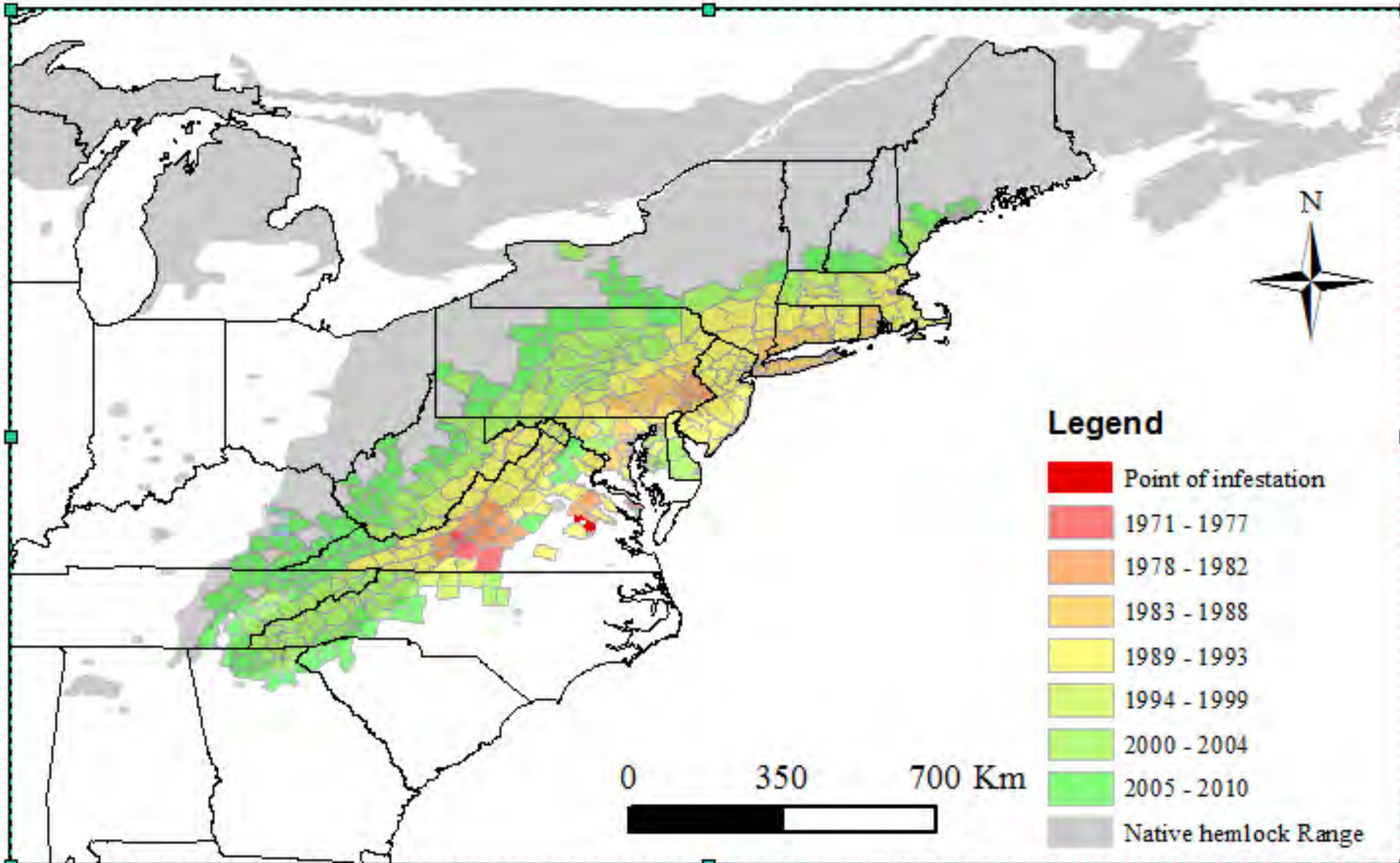
Hemlock Wooly Adelgid

Maine.gov



N
Legend
Point of infestation
1971 - 1977
1978 - 1982
1983 - 1988
1989 - 1993
1994 - 1999
2000 - 2004
2005 - 2010
Native hemlock Range
0
350
700 Km

Hemlock forest trajectories

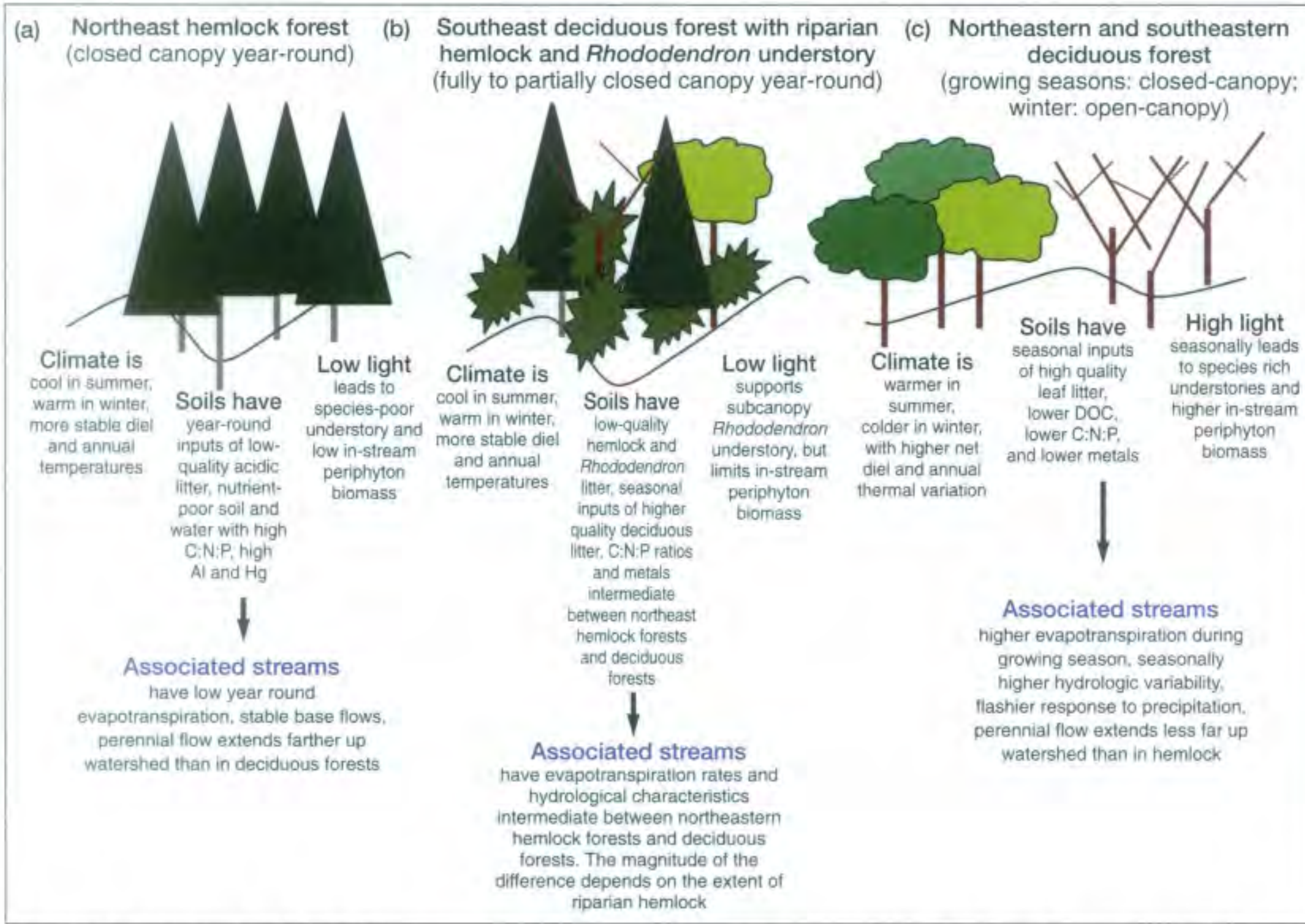


Figure 2. *Conceptual model of shifts in terrestrial and aquatic ecosystem processes following loss of eastern hemlock from (a) northern and (b) southern forests, and (c) conversion to hardwood-dominated stands.*

Loss of Foundation Species: Consequences for the Structure and Dynamics of Forested Ecosystems
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In-stream LW & HWA

Table V. Large wood loads from forested watersheds in eastern USA region[a]

Location	n	A (km^2)	Frequency (#/100m)	Density (#/m^2)	Wood volume (m^3/100 m)	Wood volume (m^3/m^2)	Jams/100m	HWA present	Source
Central Appalachian Mountain Region	23	4.1	39	0.09	3.88	0.007	3	yes	This study
15 state region along eastern US extending from Alabama to Maine	47					0.004		yes	Evans *et al.*, 2012
Adirondack Mountains, New York	1	7.4	35				3.2		Warren and Kraft, 2008
White Mountains, New Hampshire and Adirondack Mountains, New York	28	0.05	29		3.35	0.007	2.9		Warren *et al.*, 2009
Connecticut	5	5.2	16		3.15		5.2		Costigan and Daniels, 2013
Tennessee, Southern Appalachian Mountain Region	2	2.4				0.008; 0.034			Silsbee and Larson, 1983
North Carolina, Southern Appalachian Mountain Region	11	4.3			14.85				Hedman *et al.*, 1996
Coweeta Hydrologic Laboratory, North Carolina, Southern Appalachian Mountain Region	8					0.016		yes	Webster *et al.*, 2012

[a]Values are averages over streams or rivers in each study (n). Values from Warren and Kraft (2008) are an average over a four-year monitoring period. Values from Costigan and Daniels (2013) are an average of the five of the seven streams in the study with drainage areas < 9 km^2. Values in Silsbee and Larson (1983) are for streams with logged and unlogged riparian areas, respectively. Values from Webster *et al.* (2012) are based on approximate LW estimates interpreted from a bar chart (Figure 5). Drainage area (A) of streams was not reported for Evans *et al.* (2012) nor Webster *et al.* (2012).

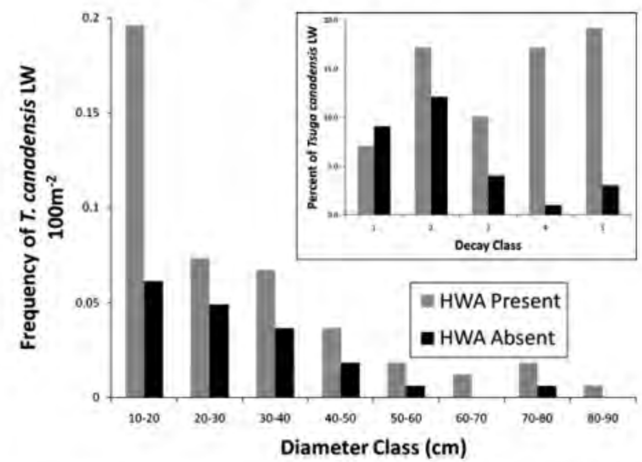

FIGURE 4. Large Wood (LW) by Diameter and Decay Classes With and Without Hemlock Wooly Adelgid (HWA) at 47 Streams From Maine to Alabama.

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EFFECTS OF EASTERN HEMLOCK DECLINE ON LARGE WOOD LOADS IN STREAMS OF THE APPALACHIAN MOUNTAINS

Daniel M. Evans, C. Andrew Dolloff, W. Michael Aust, and Amy M. Villamagna[2]

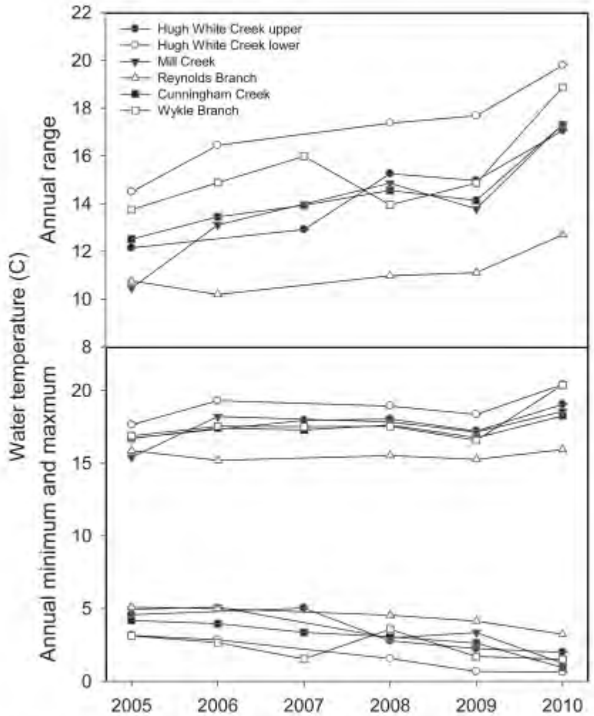


FIG. 1.—Upper panel: Trends over time in annual range in stream water temperature in small streams affected by hemlock death. Lower panel: Trends over time in annual minimum and maximum stream water temperatures

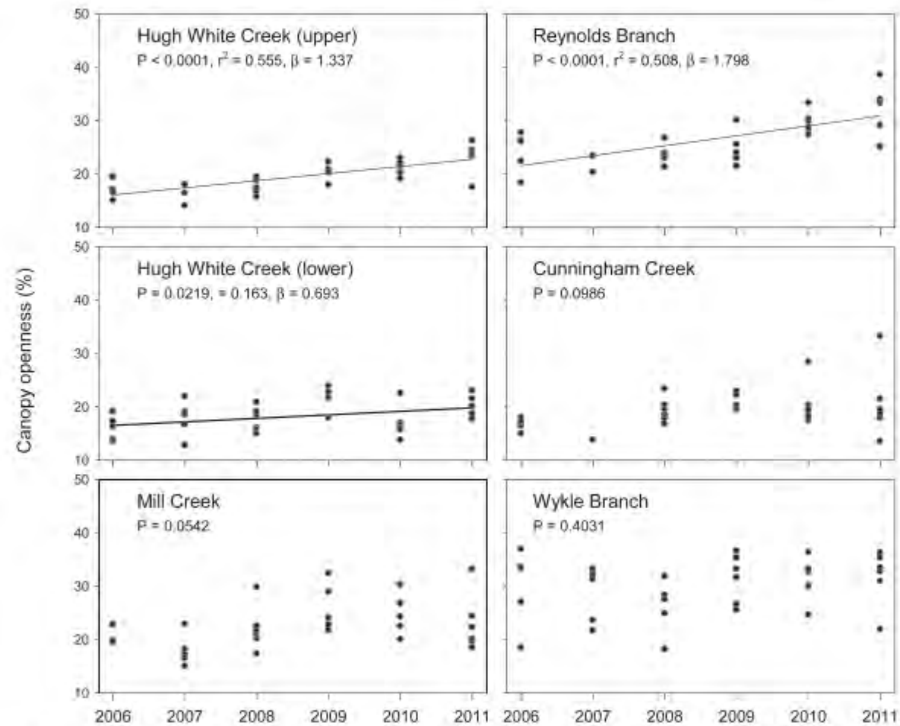


FIG. 4.—Linear regression of canopy openness over time for small streams affected by hemlock mortality. Each point is from a single photograph (β is slope of relationship)

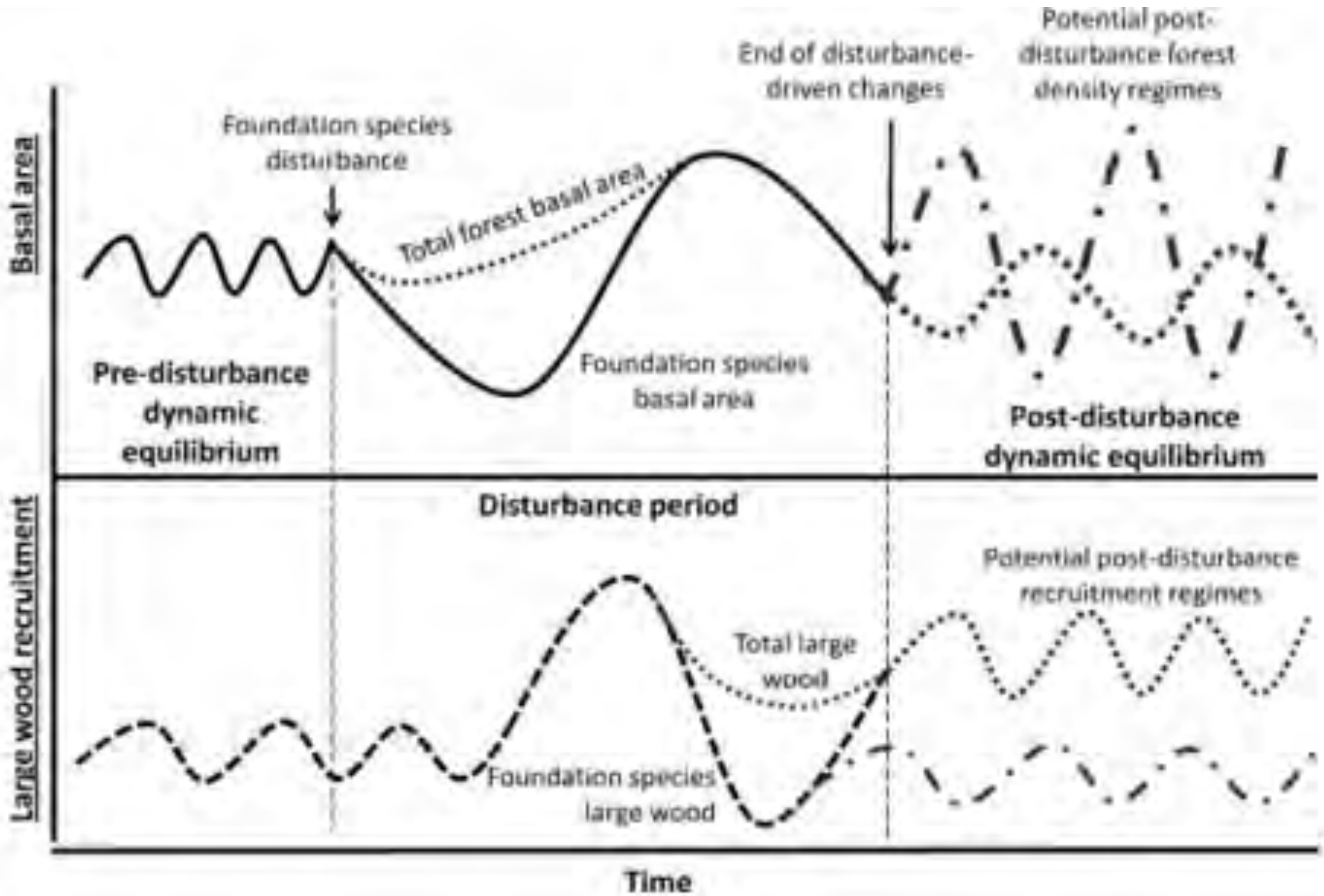
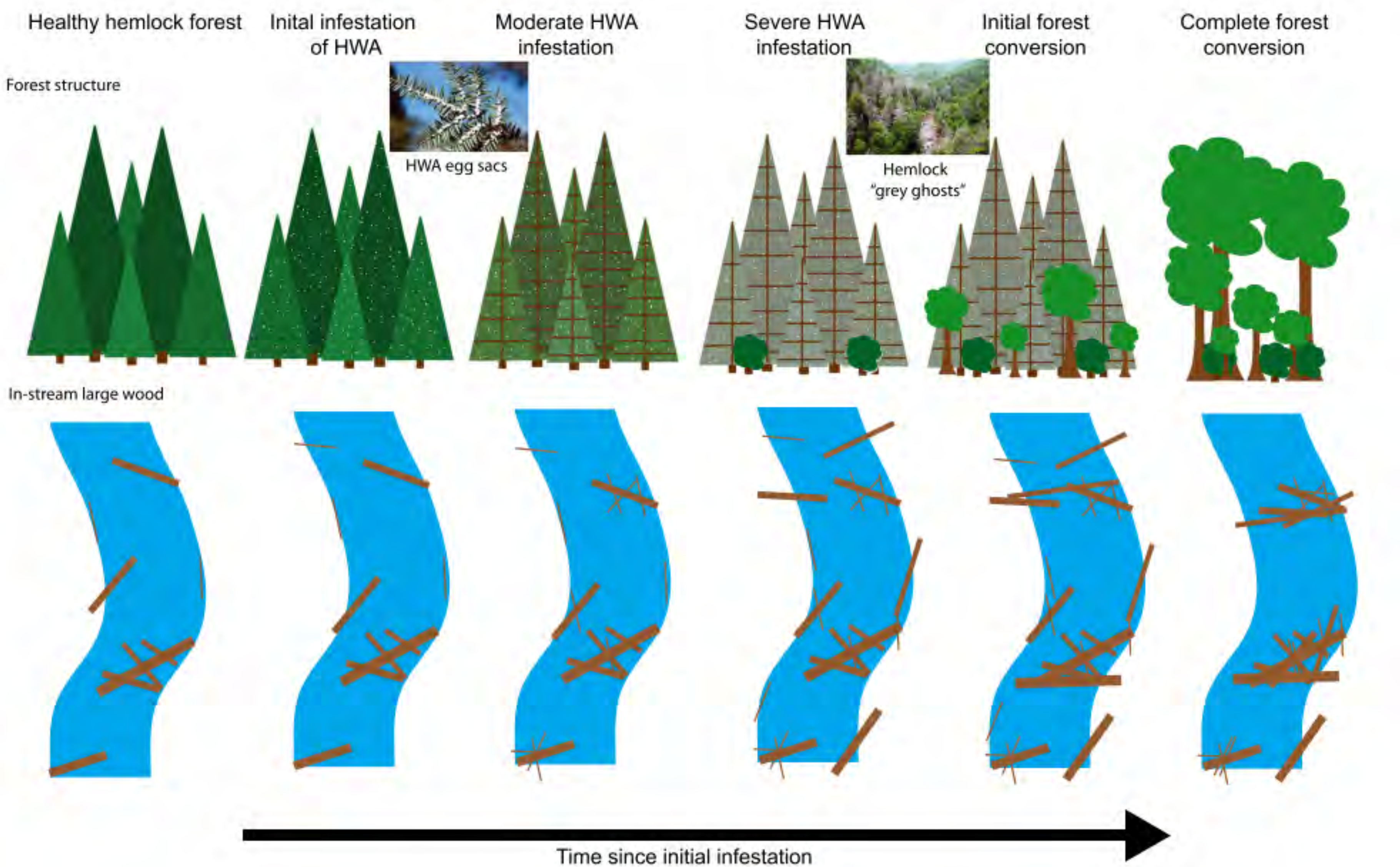


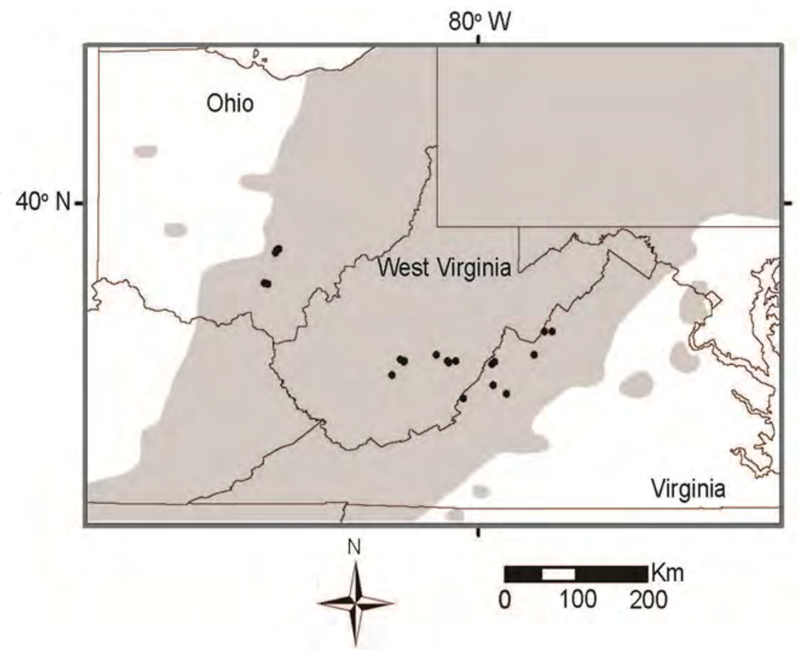
FIGURE 1. Conceptual Model Illustrating the Effects of an Episodic Disturbance to a Foundation Tree Species on Forest Basal Area (upper panel) and Instream Large Wood Recruitment (lower panel) Through Time.

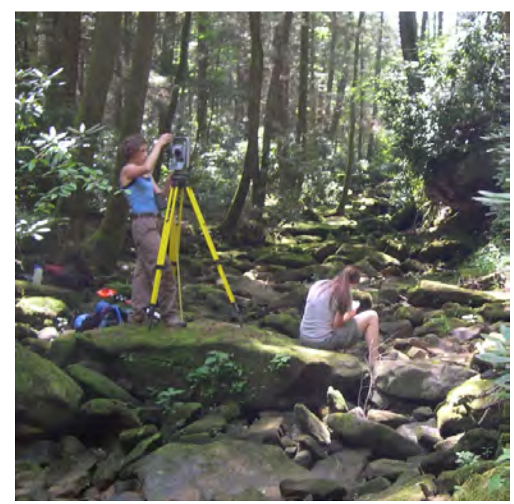
Conceptual framework



Study sites/Methods

- 24 sites; 8 in VA, WV, and OH
- Second or third-growth eastern hemlock forests
  - average stand age of 113 years
- Standard wood survey
- PCA, MLR, ANOVA



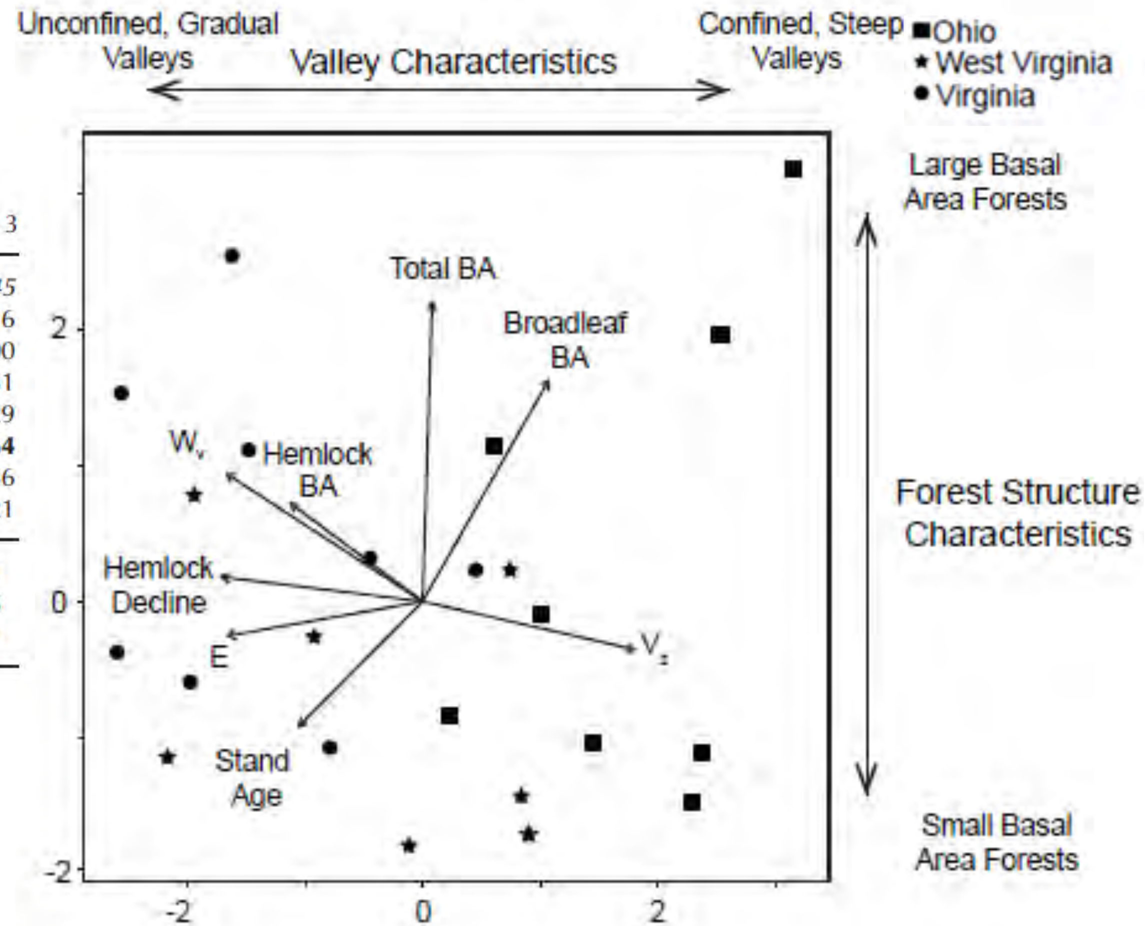


LW recruitment

- Attributes that introduce LW

(A)

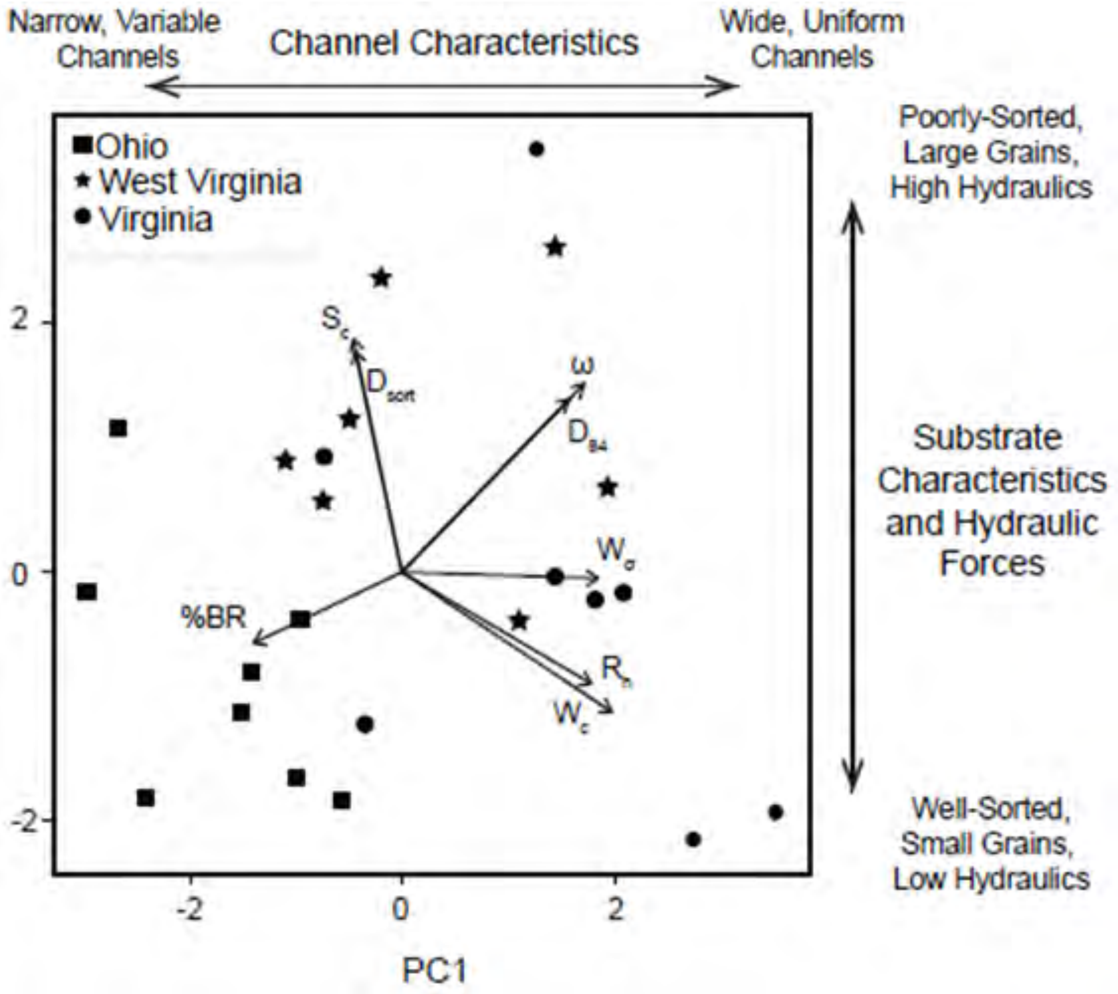
Recruitment	PC 1	PC 2	PC 3
E	*−0.42*	0.00	*−0.45*
S_v	*−0.43*	0.30	−0.16
W_v	*0.46*	−0.11	0.00
Hemlock decline	*−0.44*	0.00	−0.31
Age	−0.27	−0.29	0.29
Hem BA	−0.29	0.23	**0.64**
Broad BA	0.27	**0.52**	−0.36
Total BA	0.00	**0.70**	0.21
Standard deviation	1.7	1.4	1.1
Proportion of variance (%)	35.4	23.1	15.5
Total variance explained (%)	35.4	58.6	74.1



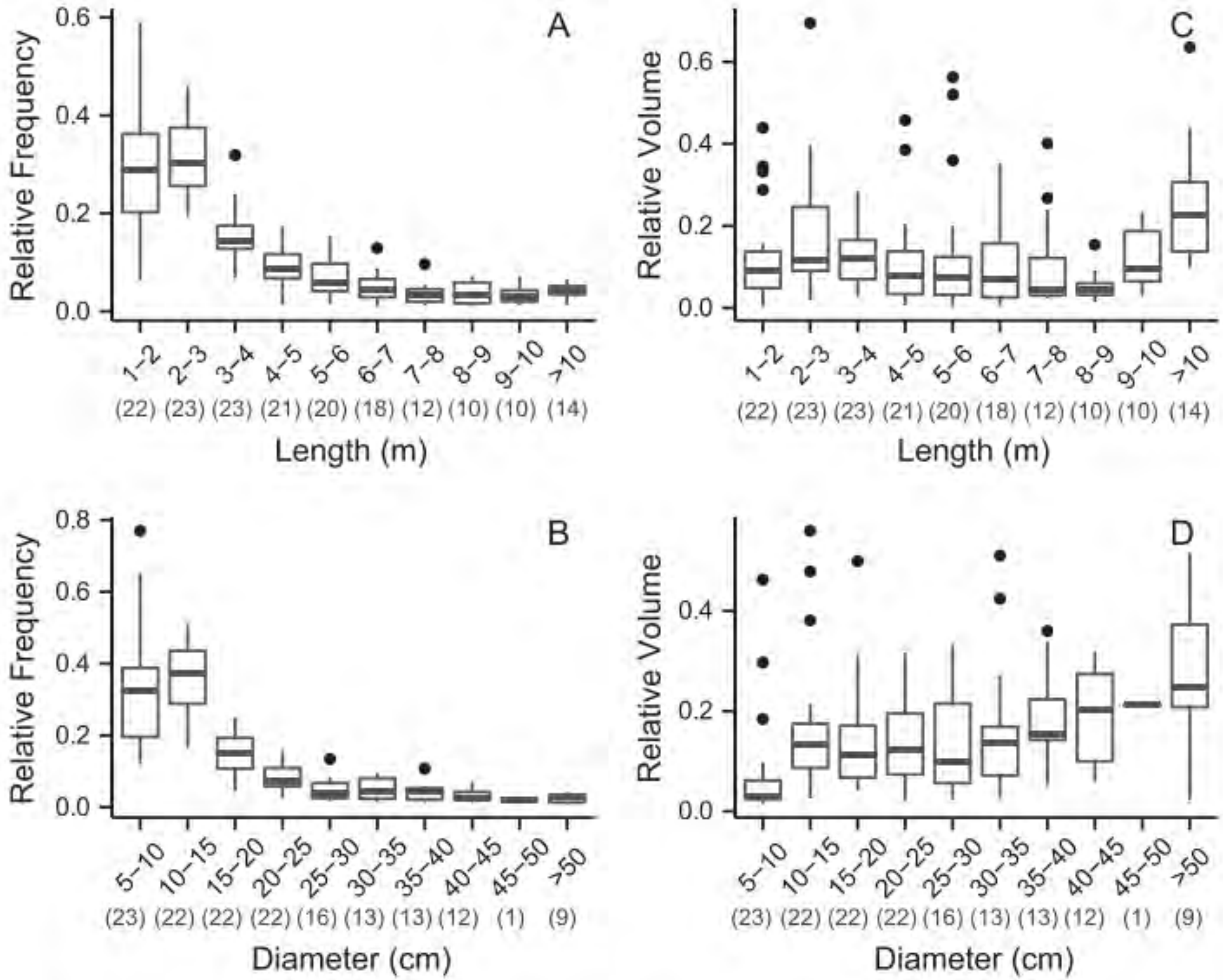
LW retention

- Attributes that keep in OR remove LW

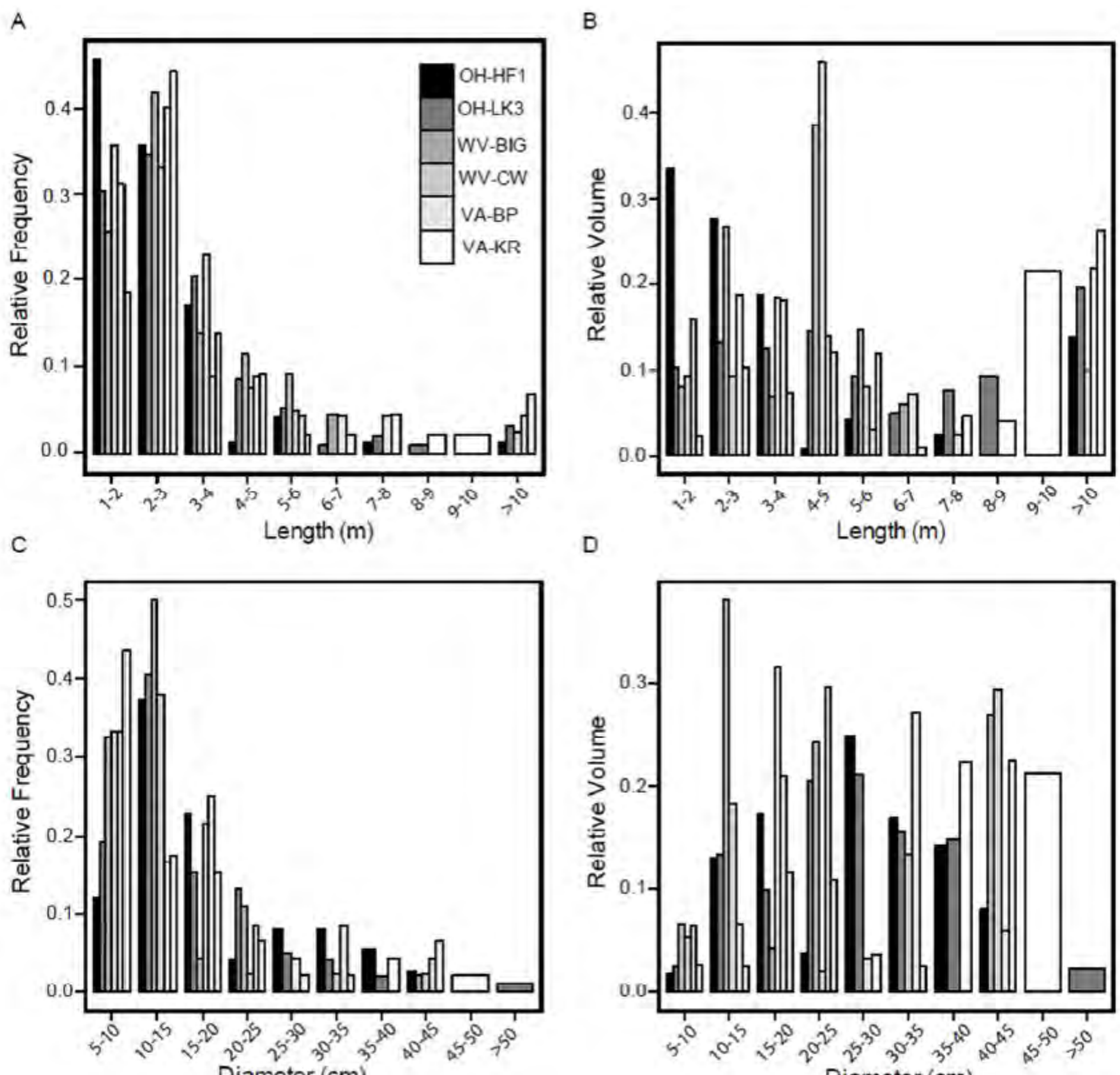
Retention	PC 1	PC 2	PC 3
ω	*−0.40*	*0.41*	0.00
W_c	*−0.46*	−0.31	−0.17
W_σ	*−0.43*	0.00	*0.44*
R_h	*−0.42*	−0.25	−0.39
S_c	0.11	**0.52**	0.29
% BR	0.33	−0.16	*−0.41*
D_{84}	−0.37	0.38	−0.34
D_{sort}	0.10	*0.49*	**−0.51**
Standard deviation	1.7	1.5	1.1
Proportion of variance (%)	37.8	27.3	14.3
Total variance explained (%)	37.8	65.1	79.4



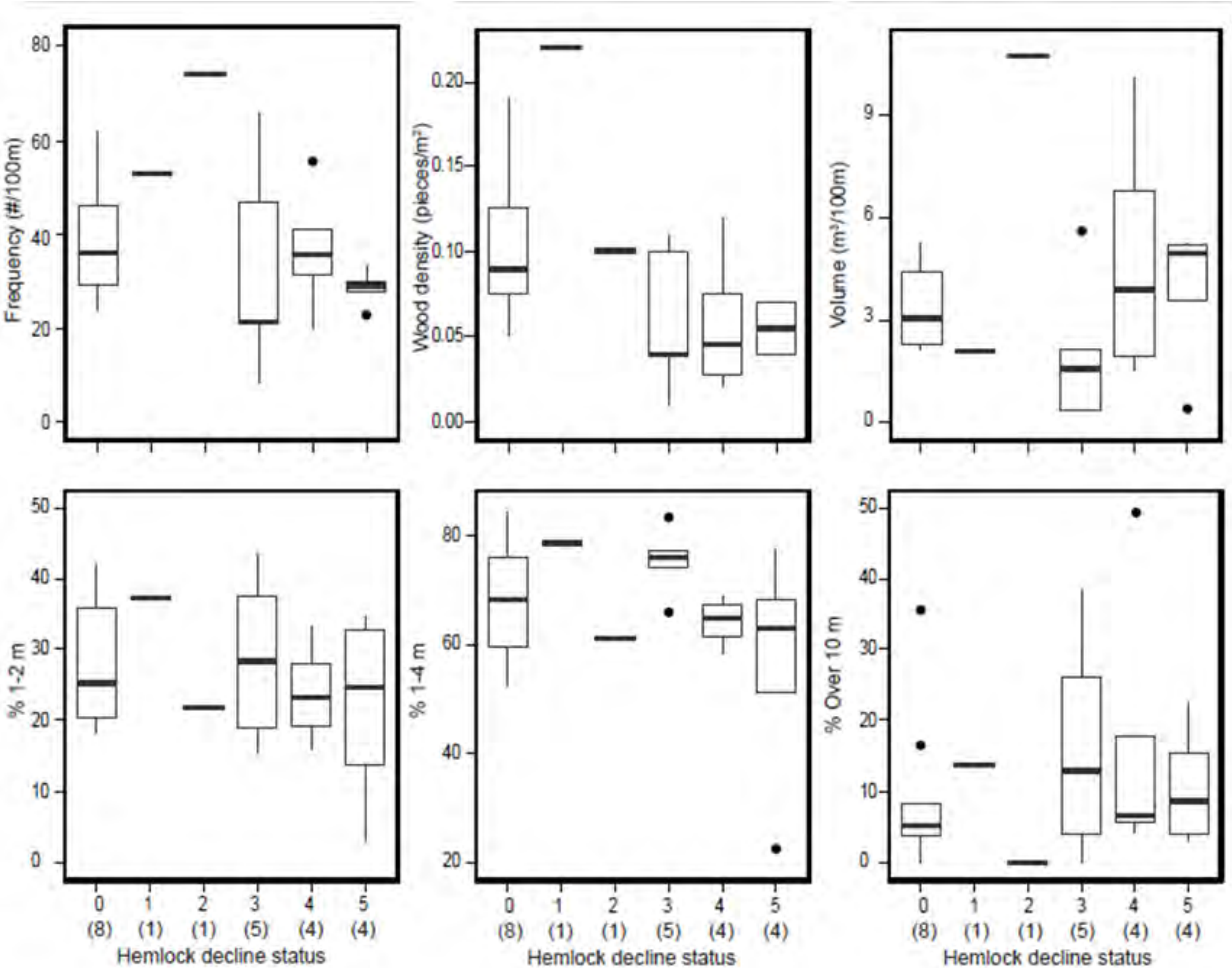
LW sizes and volumes



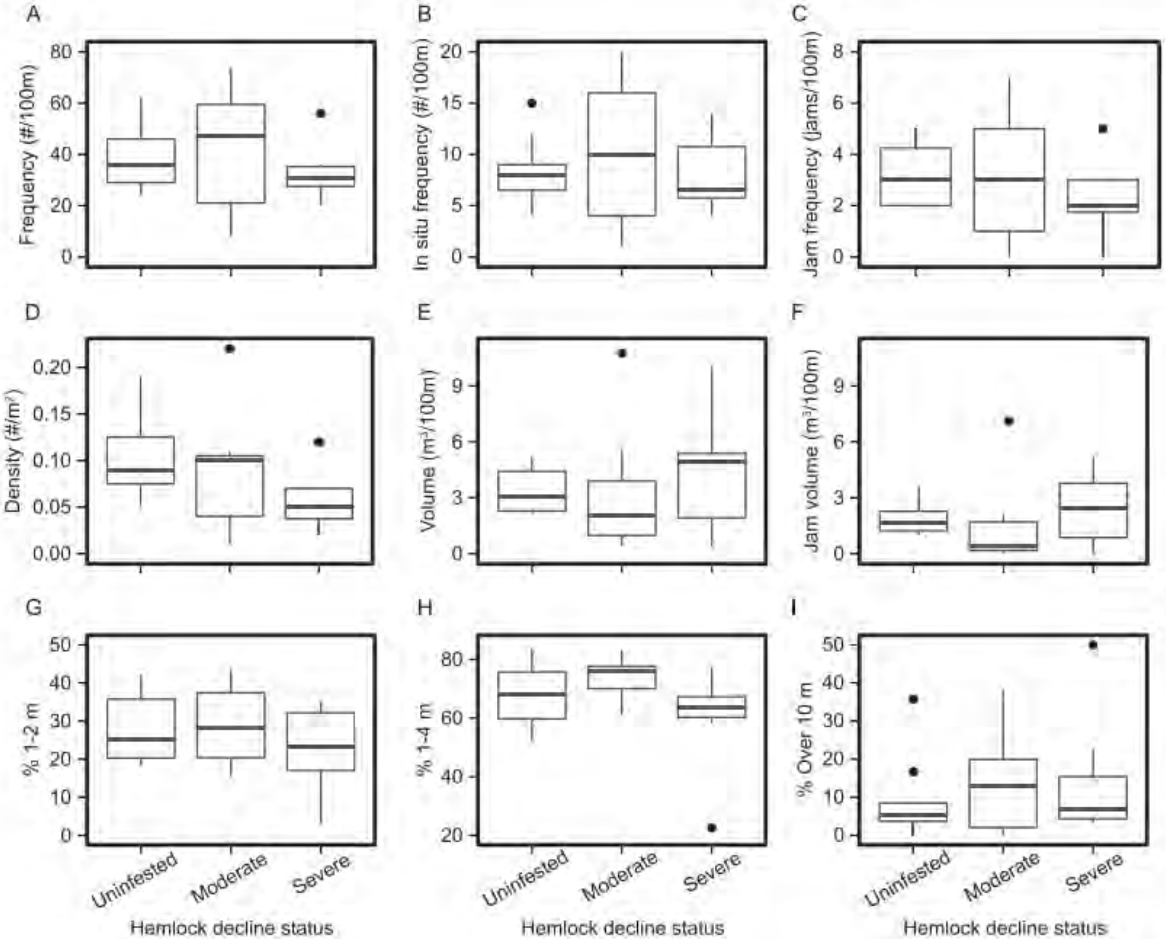
? HWA impacts ?



A
B
C
D
OH-HF1
OH-LK3
WV-BIG
WV-CW
VA-BP
VA-KR
Relative Frequency
Relative Volume
Length (m)
Diameter (cm)
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
9-10
>10
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50



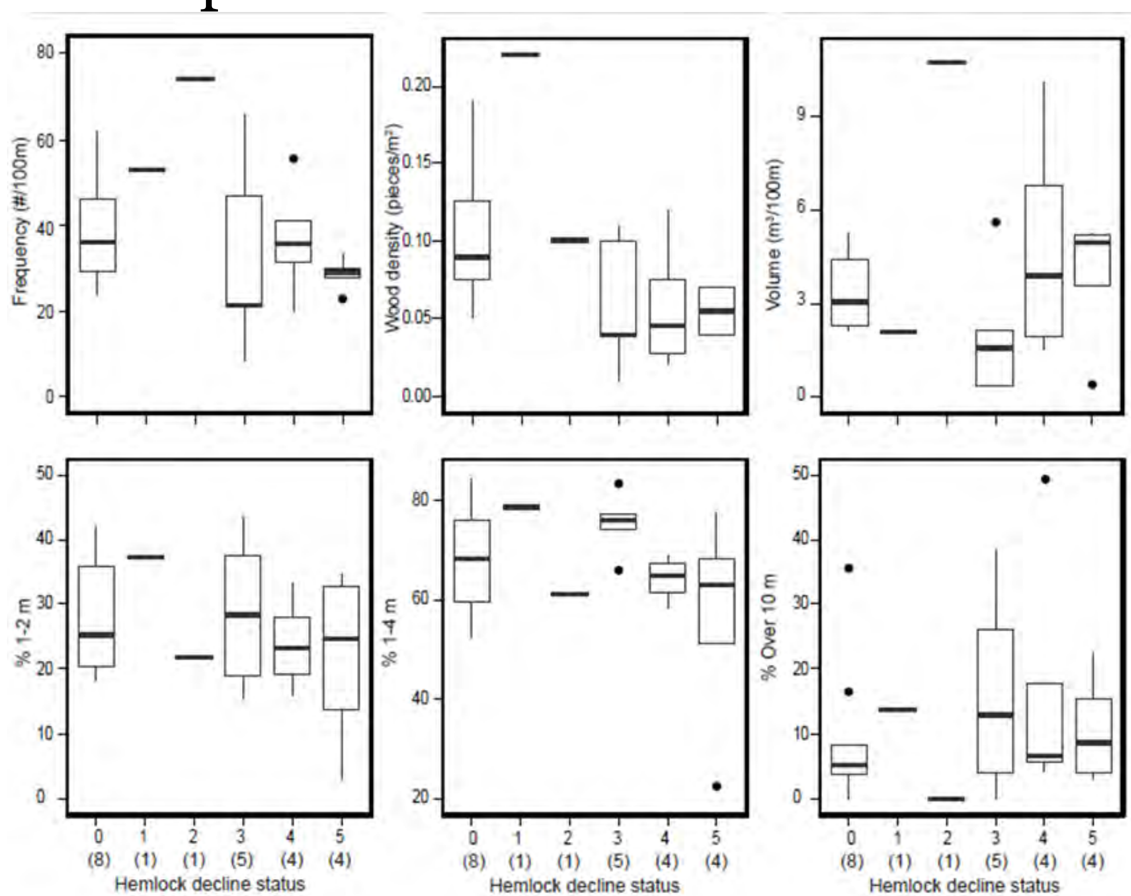
Frequency (#/100m)
Wood density (pieces/m²)
Volume (m³/100m)
% 1-2 m
% 1-4 m
% Over 10 m
0 (8) 1 (1) 2 (1) 3 (5) 4 (4) 5 (4)
Hemlock decline status
Hemlock decline status
Hemlock decline status



	a	b	SE_b	R^2	*F*	*p*-value
LW frequency (#/100m)	40.709	−3.188	4.231	0.03	0.568	0.46
In situ frequency (#/100m)	8.951	−0.125	1.260	0.00	0.010	0.92
Jam frequency (#/100m)	3.370	−0.500	0.452	0.06	1.224	0.28
LW density (pieces/m^2)	**0.107**	**−0.024**	**0.013**	**0.15**	**3.698**	**0.07**
LW volume (m^3/100m)	3.192	0.494	0.693	0.02	0.508	0.48
Jam volume (m^3/100m)	1.709	0.292	0.464	0.02	0.400	0.54
1–2 m (proportion)	29.190	−2.638	2.552	0.05	1.068	0.31
1–4 m (proportion)	70.854	−3.819	3.262	0.06	1.371	0.26
>10 m (proportion)	9.817	2.344	3.465	0.02	0.458	0.51

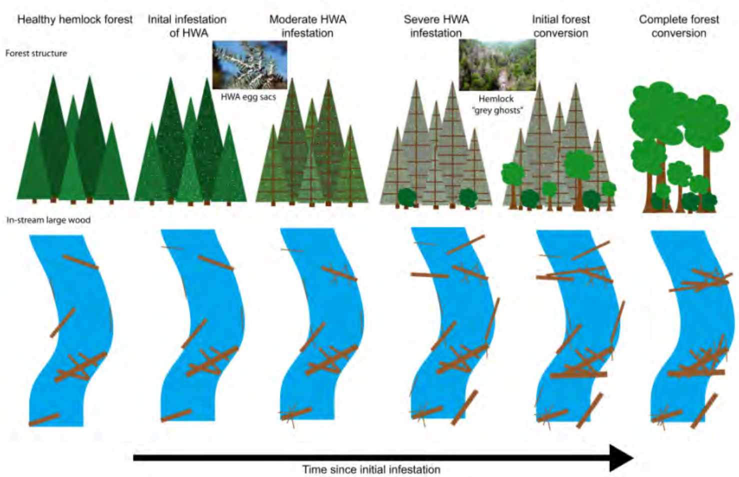
Take home messages?

- Signal of HWA impact is weak
  - Limited sample size?



Take home messages?

- Signal of HWA impact is weak
  - Limited sample size?
  - Not enough time– there is a potential lag time between toppling and recruitment



(B)

	General site characteristics				
Site	Drainage area (km^2)	Reach length (m)	Year infested with HWA	Flow regime	Hemlock decline status
OH-BT	0.1	115	-	Intermittent	0
OH-HF1	0.3	112	-	Intermittent	0
OH-HF2	0.6	123	-	Intermittent	0
OH-HF3	1.1	127	-	Perennial	0
OH-LK1	0.2	186	-	Perennial	0
OH-LK2	0.1	142	-	Intermittent	0
OH-LK3	0.5	190	-	Perennial	0
OH-SH	1.6	142	-	Perennial	0
WV-BEAR	8.4	148	1998	Perennial	2
WV-BIG	1.7	99	1998	Perennial	3
WV-BSR	5	112	2002	Perennial	3
WV-CF1	0.6	86	2002	Intermittent	1
WV-CF2	0.3	97	2002	Intermittent	1
WV-CW	0.4	116	1993	Perennial	4
WV-MBR	4.4	109	2002	Perennial	3
WV-WC	6.1	116	2002	Ephemeral	3
VA-BC1	2	95	1993	Intermittent	5
VA-BC2	2.3	108	1993	Perennial	5
VA-BP	3.6	120	1991	Perennial	4
VA-JR	19.1	190	1991	Perennial	4
VA-KR	8.4	128	1991	Ephemeral	5
VA-LPWC	9.7	115	1993	Perennial	4
VA-SC	10.2	160	1991	Perennial	5
VA-SF	11.2	169	1991	Perennial	3
Average	4.1 (4.9)	130 (31)			


Questions?