Statistical Analysis of Evergreen Invaders

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Abstract

The reproductive status, height, and distribution of seven types of invasive evergreens were analyzed using the statistical software R. In Arkansas, about 23–26% of the flora consists of non-native species (Arkansas Vascular Flora Committee 2006). Some of the most invasive plants in the southeastern United States are woody ornamentals like the ones studied in this paper. This was a collaborative effort with a Henderson State University undergraduate student and a biology professor.

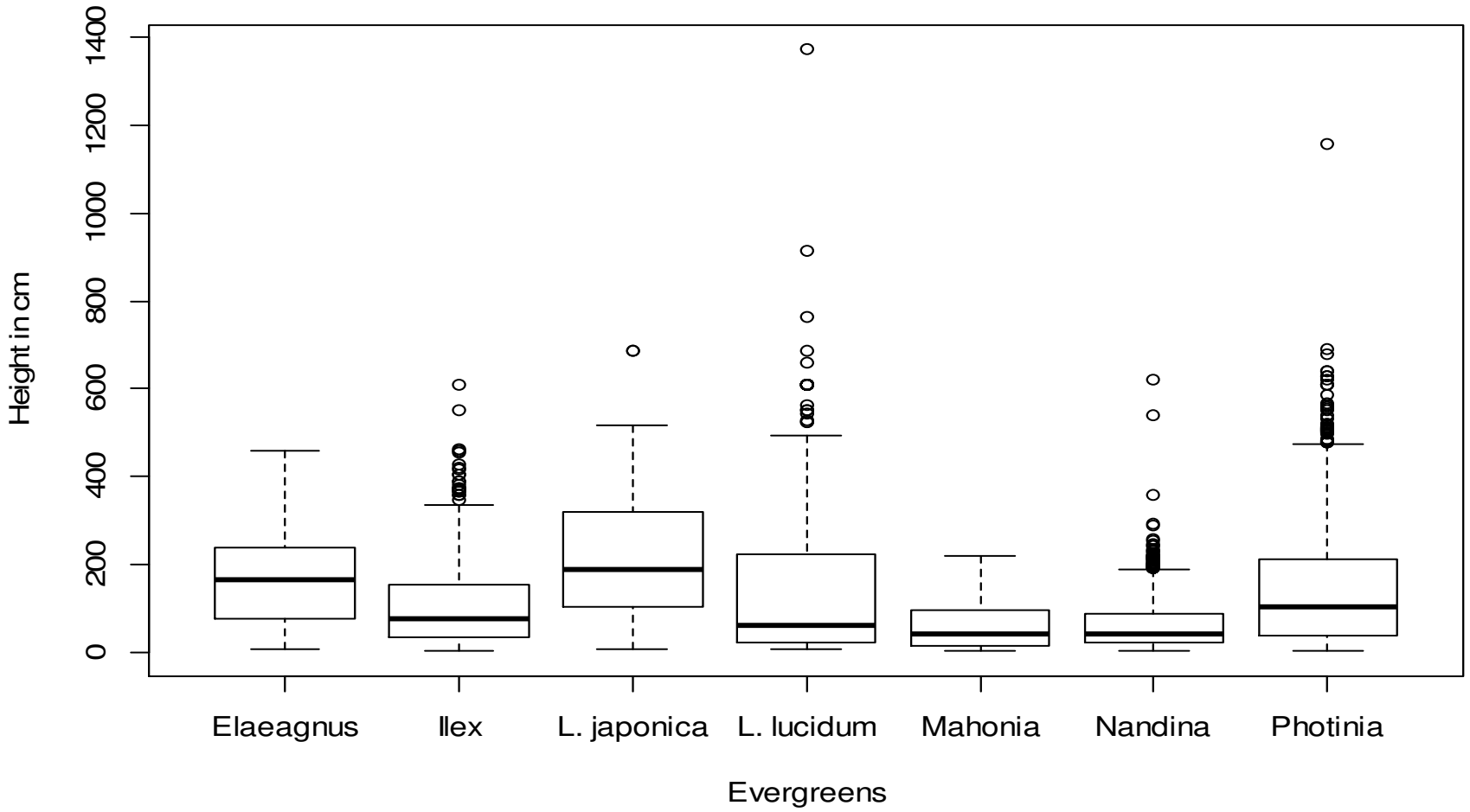
Nandina domesticus

- Non-reproductive: no berries
- Reproductive: berries present

Variables Measured (n=5765)

- Area (Arkadelphia, Hot Springs)
- Site (1–46)
- Species (Elaeagnus, Ilex, L. Japonica, L. lucidum , Mahonia , Nandina, Photinia)
- Reproductive (Yes, No)
- Height in cm

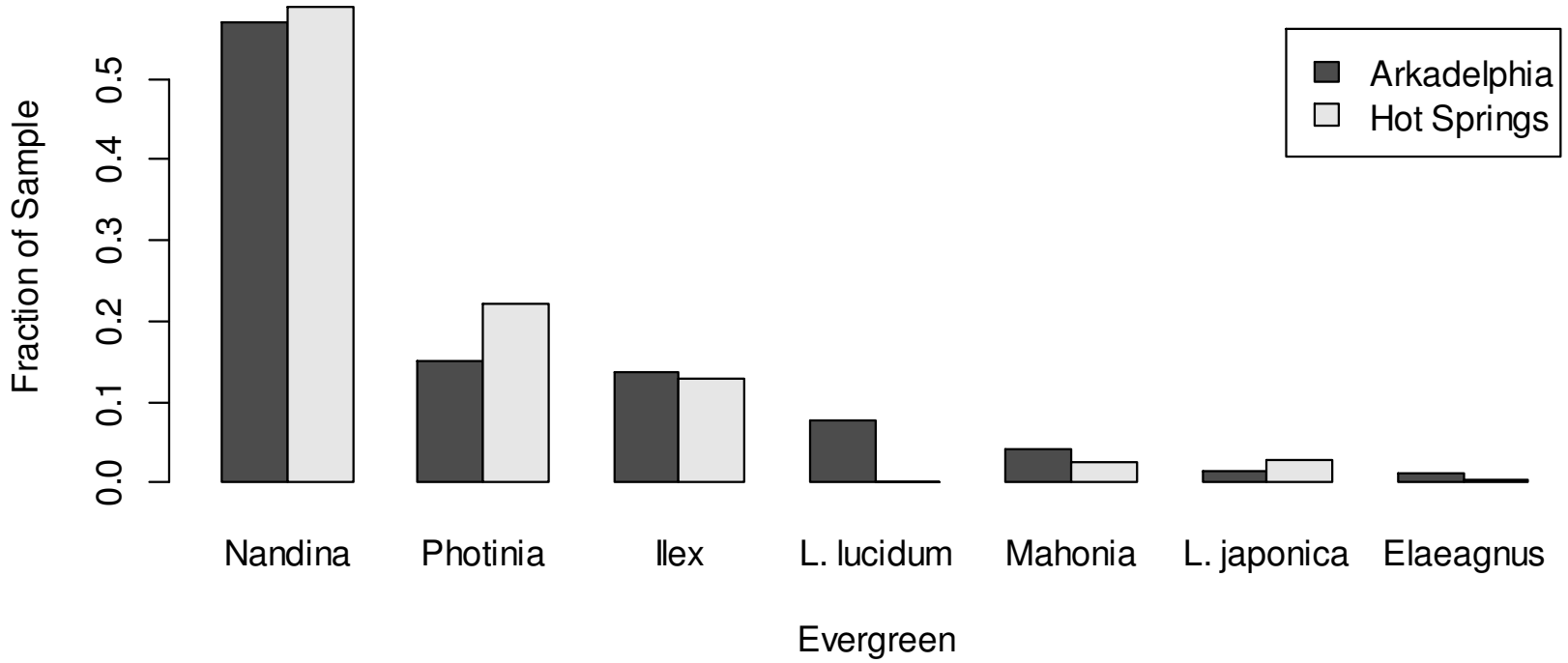
Height ~ Species Box Plots



Summary Statistics

Plant	Sample Size	Median Height (cm)	IQR (cm)	Reproductive Rate
Elaeagnus	49	163	165	0.18
Ilex	770	75	123	0.07
L. japonica	119	188	216	0.13
L. lucidum	264	59	198	0.05
Mahonia	197	42	83	0.31
Nandina	3327	43	68	0.38
Photinia	1039	102	176	0.07

Sample Size Distribution
~ Species + Area Bar Graph



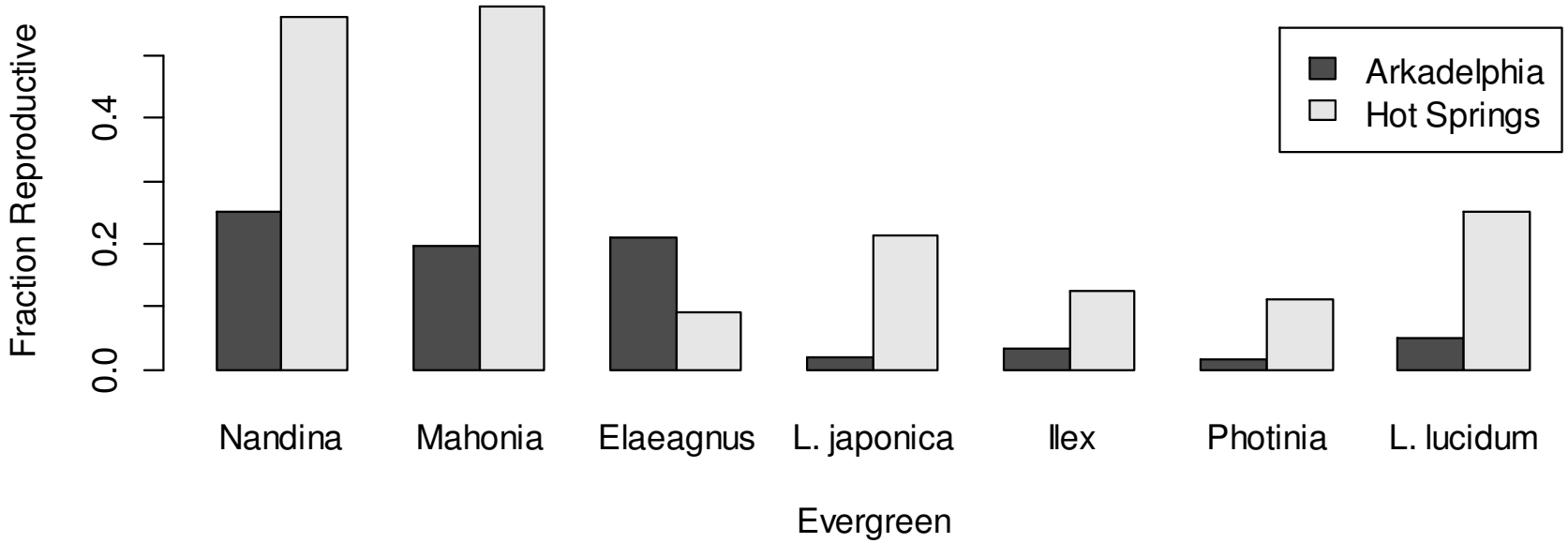
Sample Size Distribution ~ Species + Area Chi-Squared Test

- $\chi 2 = 249$, df = 6, p-value < 2×10^{-16}
- Standardized residuals

Plant	Arkadelphia	Hot Springs
Nandina	-1.5 (1912)	1.5 (1415)
Photinia	-6.9 (507)	6.9 (532)
Ilex	0.6 (457)	-0.6 (313)
L. lucidum	13.6 (260)	-13.6 (4)
Mahonia	3.4 (138)	-3.4 (59)
L. japonica	-3.8 (49)	3.8 (70)
Elaeagnus	2.7 (38)	-2.7 (11)

The observed frequencies are in parentheses.

Reproductive Rate Distribution ~ Species + Area Bar Graph

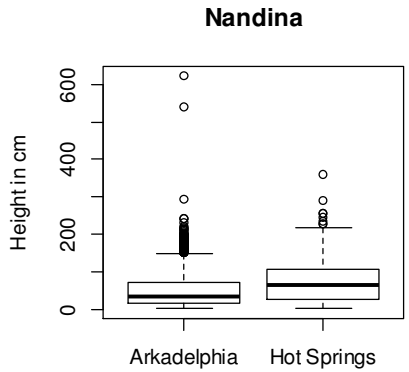


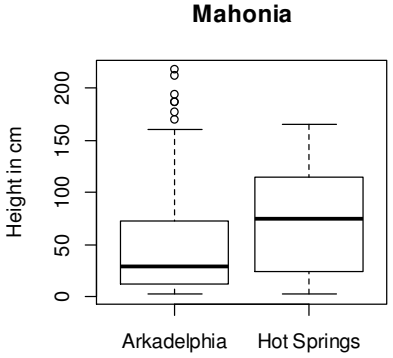
Reproductive Rates
2-Proportion Test on Area

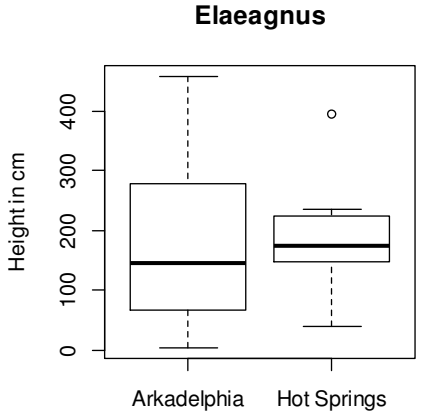
Plant	Arkadelphia	Hot Springs	χ^2 (df=1)	P-value
Nandina	0.25 (1912)	0.56 (1415)	326	2×10^{-16}
Mahonia	0.20 (138)	0.58 (59)	26	3×10^{-07}
Elaeagnus	0.21 (38)	0.09 (11)	0.21	0.65
L. japonica	0.02 (49)	0.21 (70)	7.7	0.005
Ilex	0.03 (457)	0.12 (313)	23	2×10^{-06}
Photinia	0.02 (507)	0.11 (532)	35	3×10^{-09}
L. Lucidum	0.05 (260)	0.25 (4)	0.42	0.52

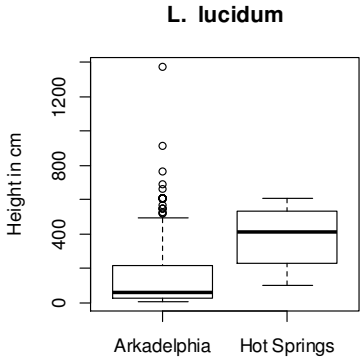
The sample sizes are in parentheses.

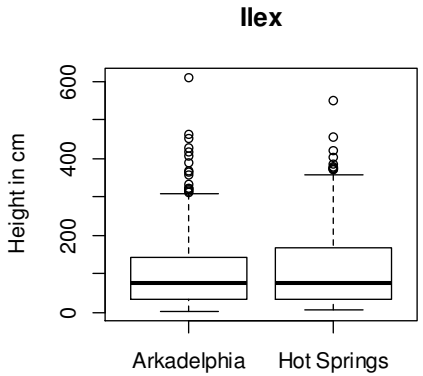
Heights ~ Area Box Plots

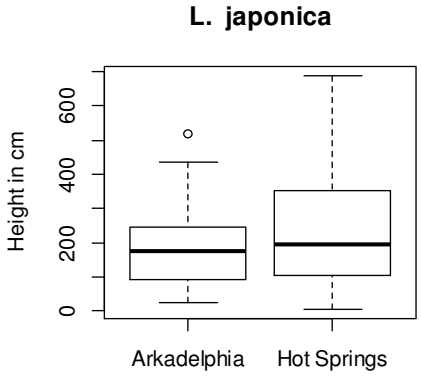


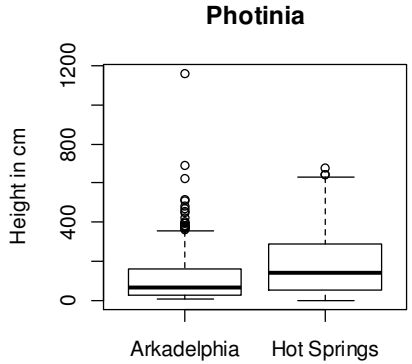








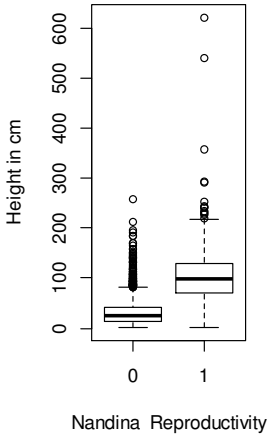




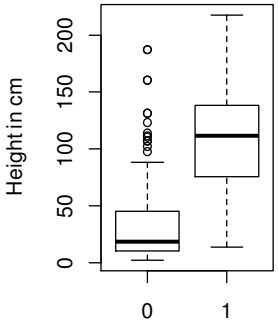
Height ~ Area
Wilcoxon Rank-Sum Test

Plant	Median Height in Hot Springs	Median Height in Arkadel.	(H.S-Ark.) Location (cm)	Wilcoxon Rank Sum W	P value
Nandina	66 (1415)	33 (1912)	19	1032492	2×10^{-16}
Mahonia	75 (59)	29.5 (138)	26	3018	0.004
Elaeagnus	174 (11)	146 (38)	15	189.5	0.65
L. lucidum	411.5 (4)	58 (260)	303	187	0.03
Ilex	76 (313)	74 (457)	4	69079	0.42
L. japonica	196.5 (70)	174 (49)	26	1527	0.31
Photinia	137.5 (532)	69 (507)	47	98155	3×10^{-14}

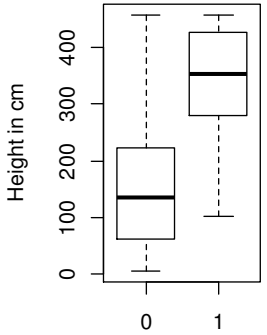
Height ~ Reproductive Box Plots



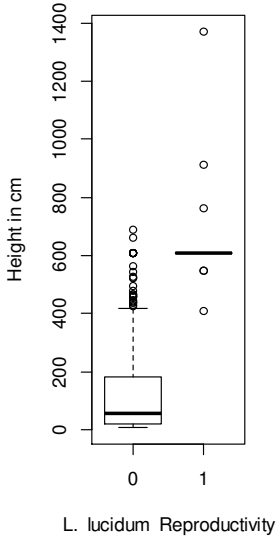
Nandina Reproductivity



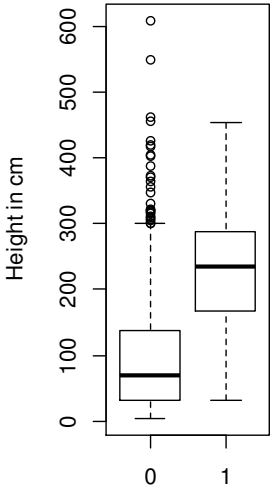
L. Mahonia Reproductivity



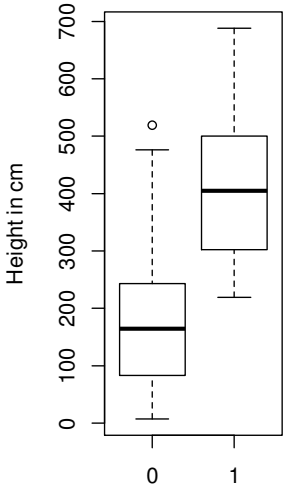
Elaeagnus Reproductivity



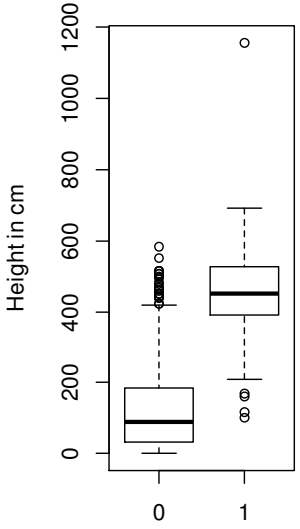
L. lucidum Reproductivity



Ilex Reproductivity

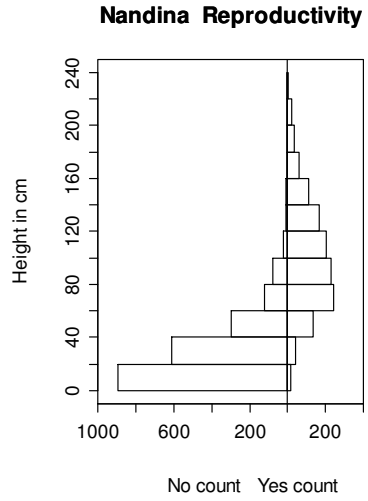


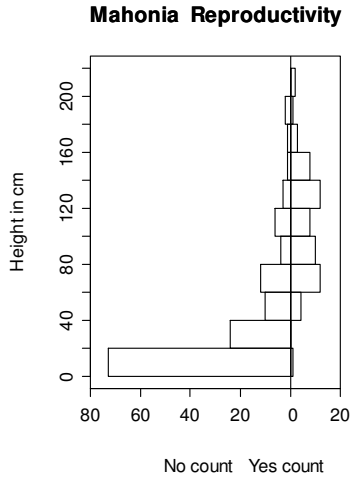
L. japonica Reproductivity

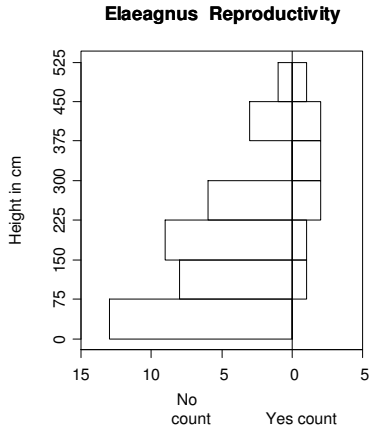


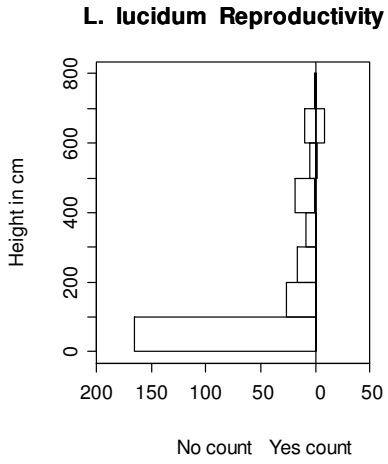
Photinia Reproductivity

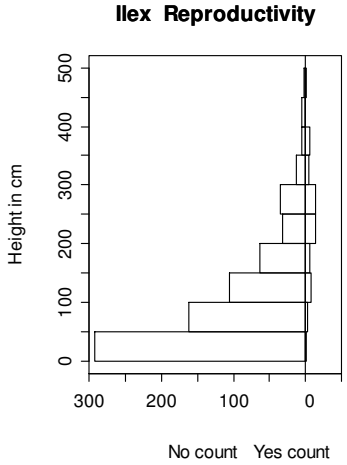
Height ~ Reproductive Rate Histograms

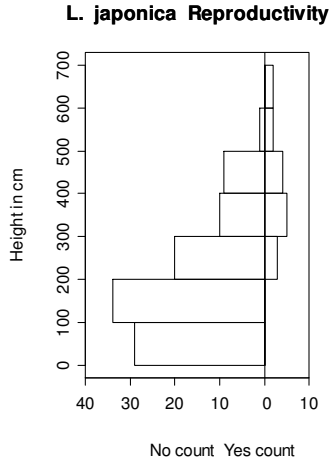


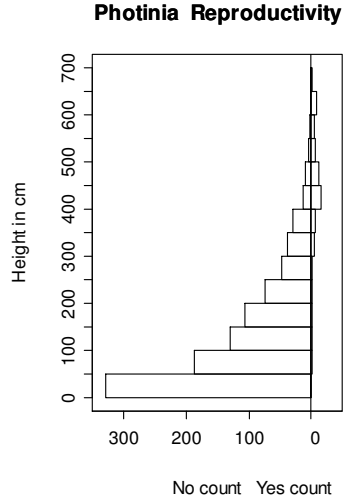








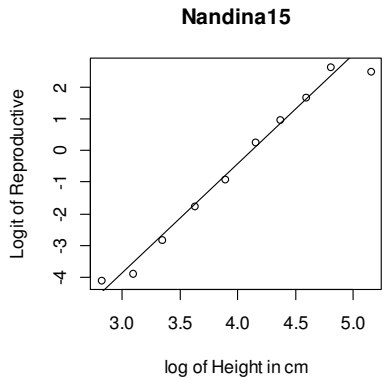


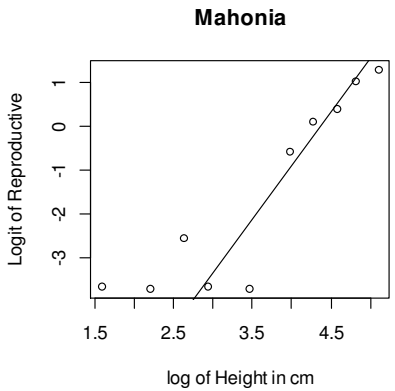


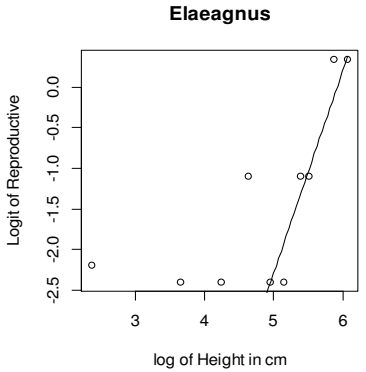
Reproductive Rate ~ Height Wilcox Rank-Sum Test

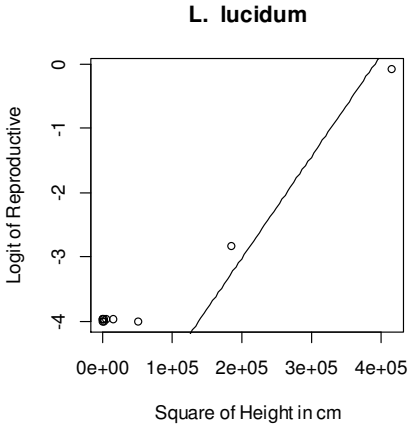
Plant	Median Height of Reproductive (cm)	Median Height of non-Reproductive (cm)	(Height Rep. –not Rep.) Location (cm)	Wilcoxon Rank Sum W	P value
Nandina	99 (1275)	25 (2052)	69	1.8e5	$<2\times10^{-16}$
Mahonia	112 (61)	18.5 (136)	77	796	$<2\times10^{-16}$
Elaeagnus	352 (9)	134 (40)	192	55	0.001
L. lucidum	610 (14)	55.5 (250)	548	102	3×10^{-9}
Ilex	235 (54)	69 (716)	149	5338	$<2\times10^{-16}$
L. japonica	403.5 (16)	162 (103)	230	190	8×10^{-7}
Photinia	449.5 (68)	89 (971)	345	3148	$<2\times10^{-16}$

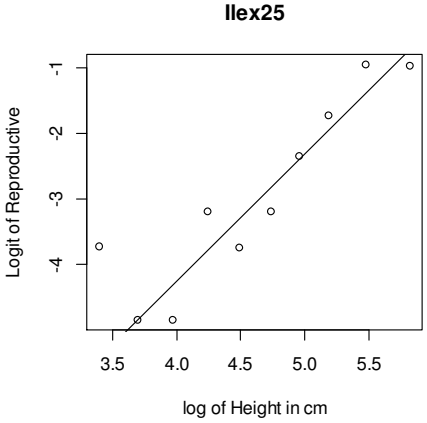
Reproductive ~ Height Logit Plots

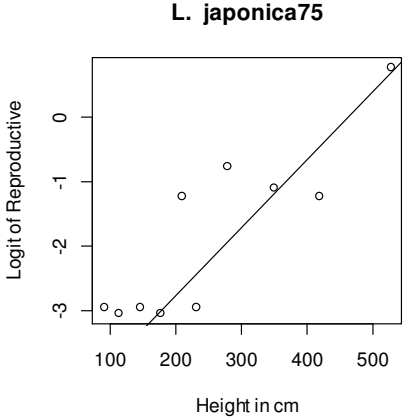


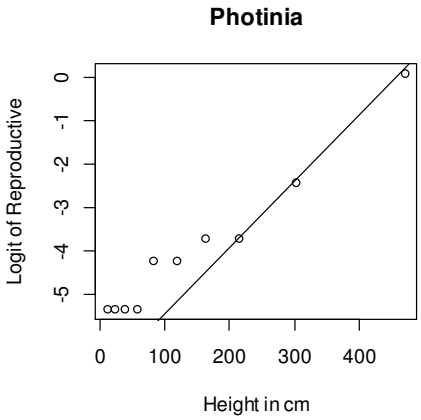












Variables in Logistic Regression

Plant	Height transformation	AIC (Height)	AIC (Height + Area)	P value (Height)	P value (Area)
Nandina15	log	2044	1932	$<2\times10^{-16}$	$<2\times10^{-16}$
Mahonia	log	141	128	2×10^{-9}	0.0002
Elaeagnus	log	38	39	0.01	NA
L. lucidum	square	51	52	4×10^{-6}	NA
Ilex25	log	301	281	2×10^{-11}	7×10^{-6}
japonica75	none	67	61	0.0002	0.03
Photinia	none	245	241	$<2\times10^{-16}$	0.0231

Coefficients & Odds Ratios

Plant	Intercept	Height	Area (HS=1)	Odds Ratio (Height)	Odds Ratio (Area)
Nandina15	-14.4	L 3.36	1.22	L 28.7	3.39
Mahonia	-11.3	L 2.42	1.75	L 11.3	5.76
Elaeagnus	-14.8	L 2.49	NA	L 12.1	NA
L. lucidum	-6.19	S 1.58×10^{-5}	NA	1.00	NA
Ilex25	-13.1	L 1.98	1.52	L 7.24	4.58
japonica75	-6.64	0.0102	2.41	1.01	11.2
Photinia	-7.55	0.0145	1.07	1.01	2.92

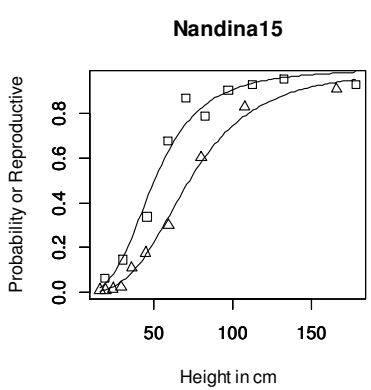
L = Height was transformed with log, S = height was transformed with square, HS = Hot Springs

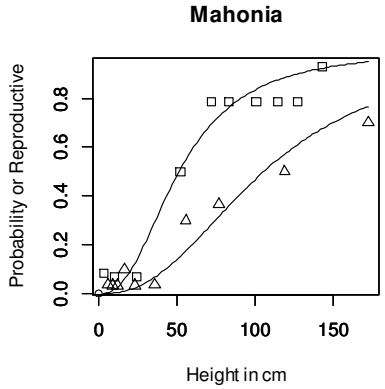
Accuracy of Logistic Models

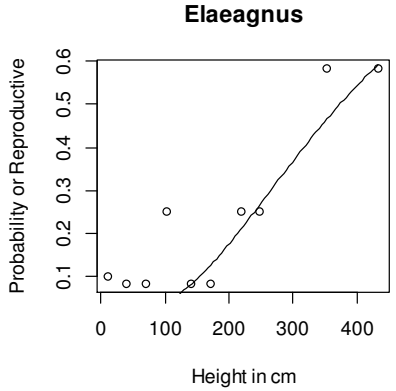
Plant	2-Way Table Accuracy	Correct Pairings
Nandina15	86% (2798)	91% (1,939,245)
Mahonia	87% (197)	90% (8296)
Elaeagnus	80% (49)	84% (360)
L. lucidum	95% (264)	96% (3500)
Ilex25	91% (622)	82% (30,672)
japonica75	85% (96)	85% (1280)
Photinia	95% (1039)	95% (66,028)

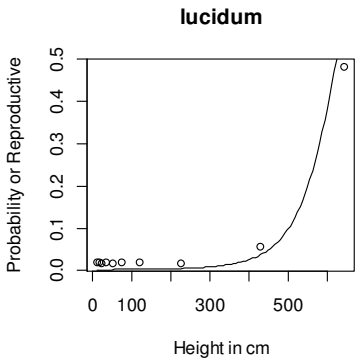
The number of comparisons are in parentheses.

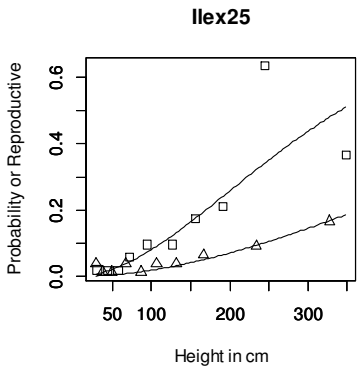
Rep ~ Height + Area

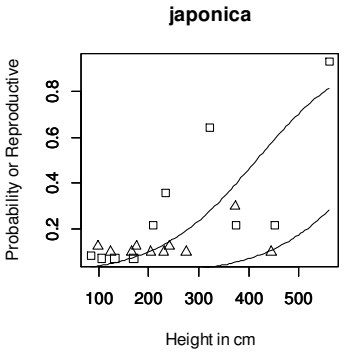


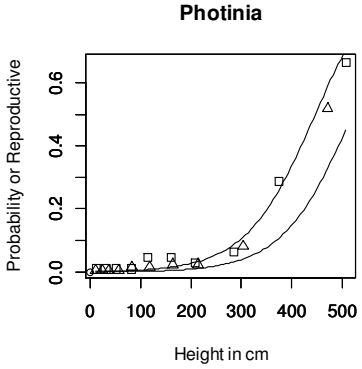












□ = Hot Springs, △ = Arkadelphia

Short Plants Excluded from Logistic Model

- L. japonica shorter than 75 cm: None shorter than 215 cm were reproductive.
- Nandina shorter than 15 cm: Height did not a significantly affect the reproductive status ($W = 2981.5$, p-value = 0.42). 2% were reproductive.
- Ilex shorter than 25 cm: None shorter than 30cm were reproductive.

Thanks

- Dr. Brett Serviss
- Jonathan Eagle
- Ellis College Planning & Advisory Committee