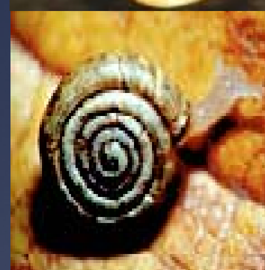
INFLUENCE OF SOIL CALCIUM ON FOREST FLOOR COMMUNITIES IN THE ADIRONDACKS





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BACKGROUND & HYPOTHESES

Calcium essential nutrient for all organisms – some taxa especially Ca-dependent

Ca depletion from forest soils due to acidic deposition is widespread

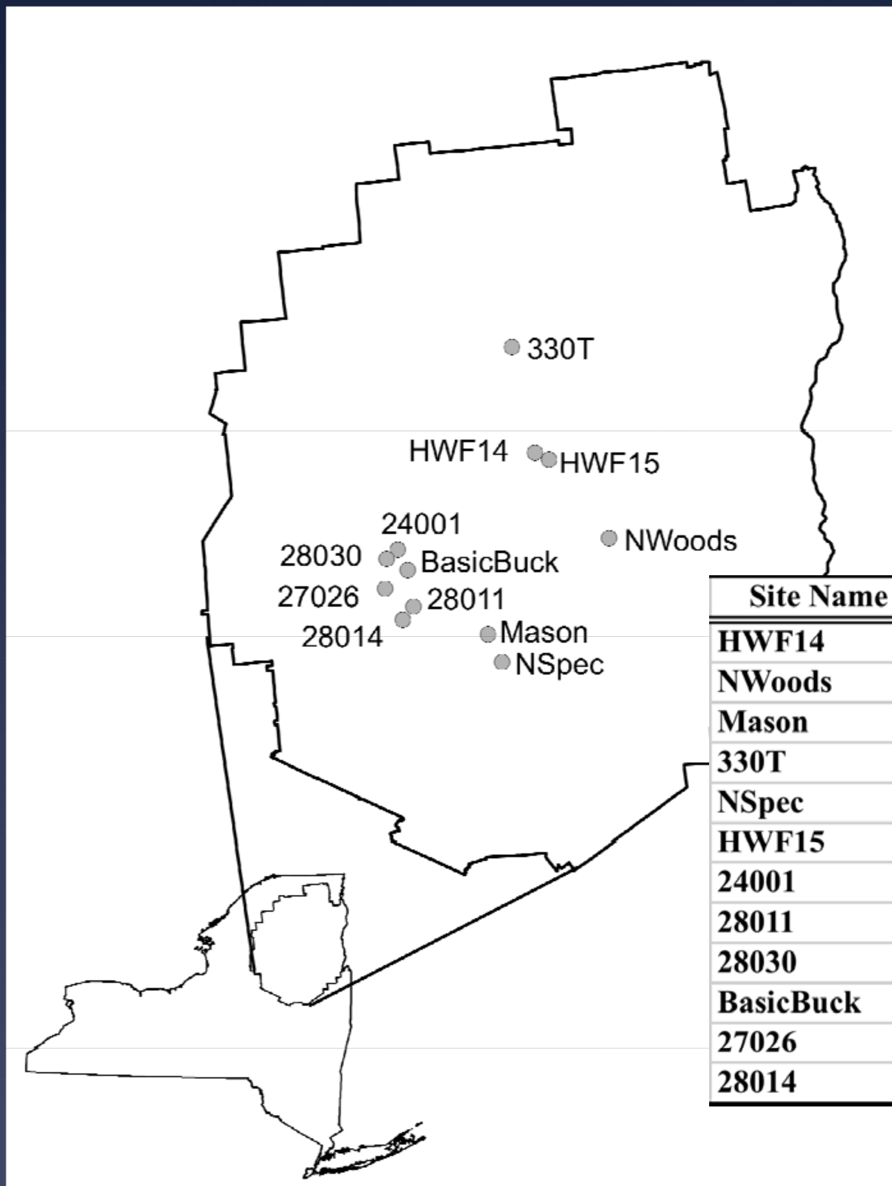
Evidence of biotic impacts of Ca depletion includes:

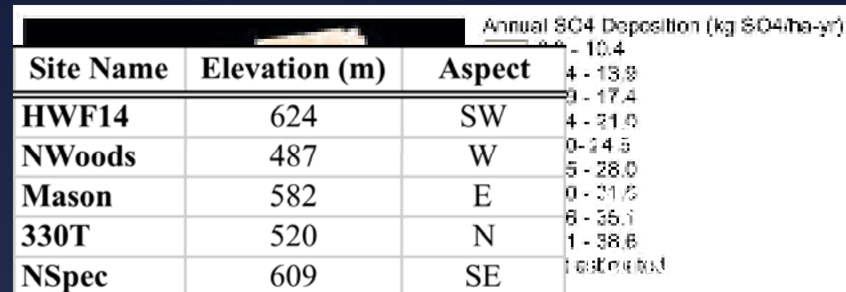
- Sugar maple decline, red spruce decline in northeastern U.S.
- Declining populations of land snails in southern Appalachians
- Changes in salamander populations in New Hampshire
- Lower fitness of passerines in Western Europe, UK and northeastern U.S.

We hypothesized that land snail and amphibian communities in upland forests would vary significantly, in terms of abundance, diversity and structure, along a soil Ca gradient in the Adirondack Mountains.

Patches of base-rich soils buffered by calcareous parent materials could serve as 'neorefugia' in an acidified landscape

STUDY SITES





Site Name	Elevation (m)	Aspect
HWF14	624	SW
NWoods	487	W
Mason	582	E
330T	520	N
NSpec	609	SE
HWF15	627	S
24001	561	NE
28011	655	N
28030	567	S
BasicBuck	646	N
27026	619	E
28014	668	N

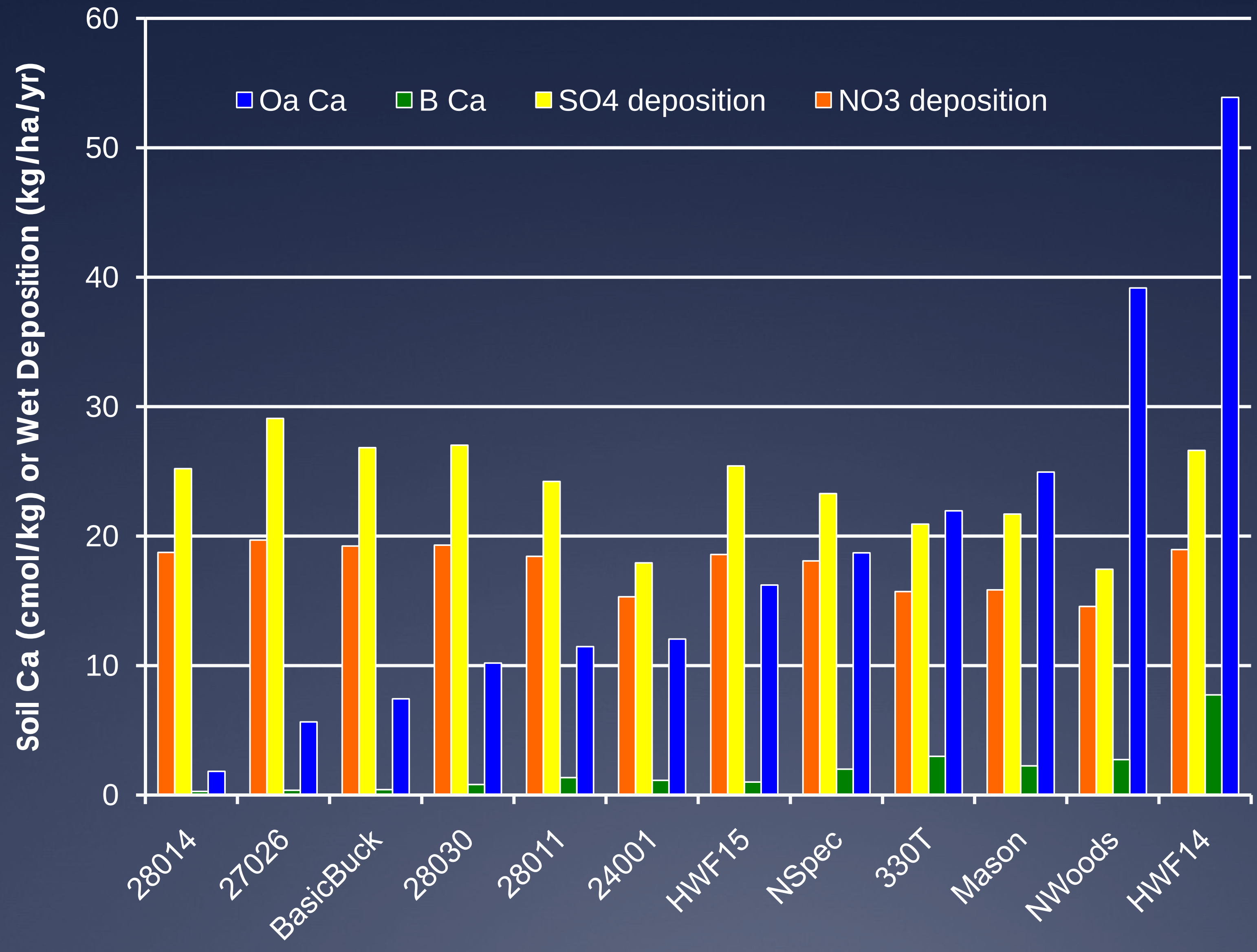
ET AL. 2002

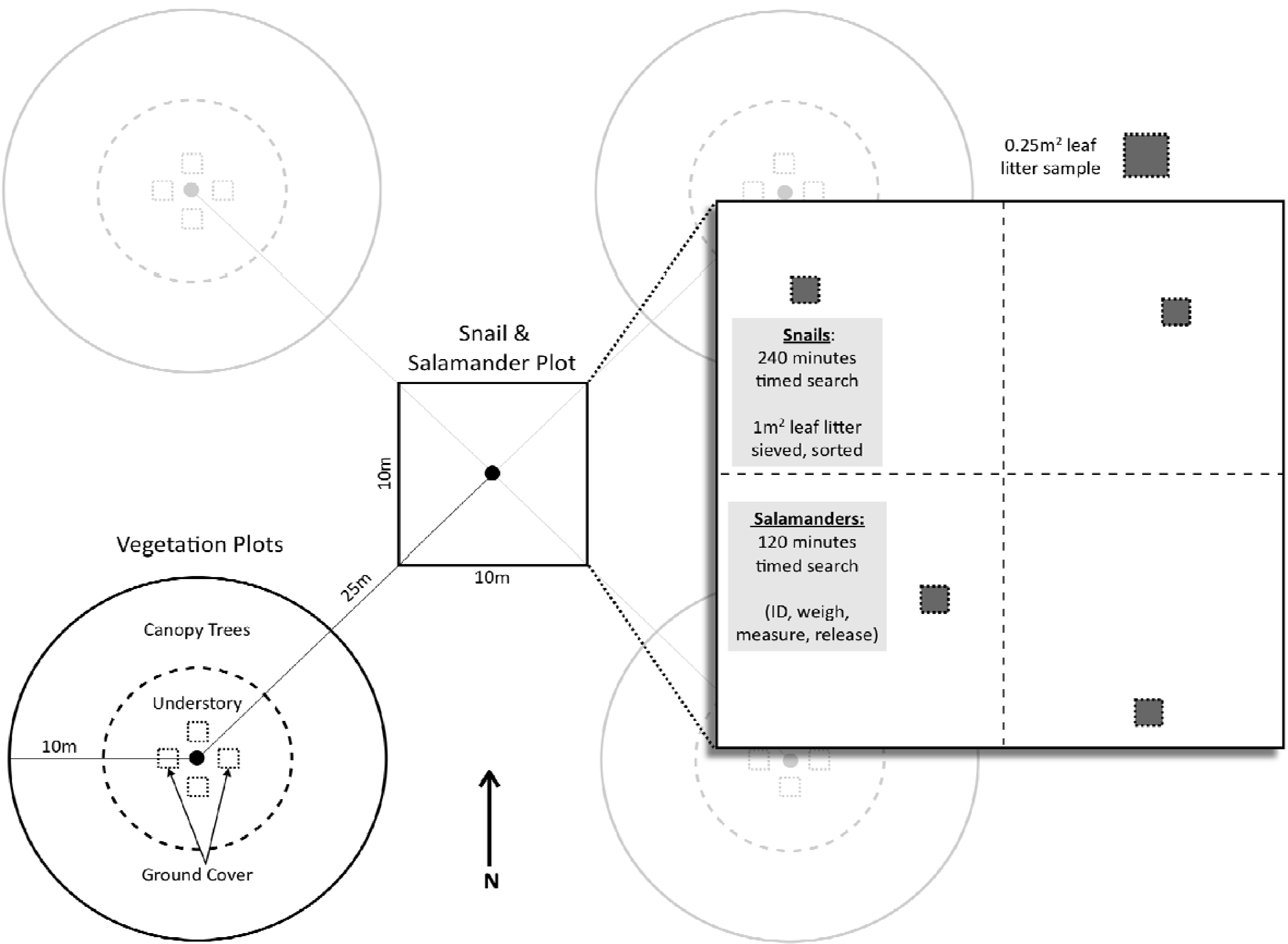
SO_4 WET DEPOSITION

Site Name	Parcel History	Stand History
HWF14	Huntington Forest 1932	Logged, softwoods 1870-1900
NWoods	NYS Forest Preserve 1885	Logged, softwoods pre-1885
Mason	NYS Forest Preserve 1871	Logged, softwoods pre-1871
330T	NYS Forest Preserve 1911	Logged, softwoods 1899-1910
NSpec	NYS Forest Preserve 1871	Logged, softwoods pre-1871
HWF15	Huntington Forest 1932	Logged, softwoods 1870-1900
24001	NYS Forest Preserve 1871	Virgin, never harvested
28011	NYS Forest Preserve 1963	Logged, pulpwood pre-1950
28030	NYS Forest Preserve 1871	Virgin, never harvested
BasicBuck	NYS Forest Preserve 1871	Virgin, never harvested
27026	NYS Forest Preserve 1960	Logged, pulpwood pre-1950
28014	NYS Forest Preserve 1963	Logged, pulpwood pre-1950

NO_3 WET DEPOSITION

STUDY SITES: Calcium and Acidic Deposition Gradients




0.25m² leaf litter sample
Snail & Salamander Plot
Snails:
240 minutes timed search
1m² leaf litter sieved, sorted
Salamanders:
120 minutes timed search
(ID, weigh, measure, release)
10m
10m
25m
Vegetation Plots
Canopy Trees
Understory
10m
Ground Cover
N

ANALYSIS

- Correlation screening at $p < 0.05$ to identify all potential effects and covariates

- Linear modeling of community variability along sampled gradients in soil Ca, acidic deposition (NO_3 and SO_4 kg ha^{-1} yr^{-1}; based on Ito et al. 2002)

- Multivariate model comparison using Akaike's Information Criterion (AICc)
    - Initial set of *a priori* models evaluated based on hypotheses
    - For each response variable, all possible models with all combinations of effect/covariate terms were compared
    - Only models with 3 or less predictor terms were considered

- Non-metric multidimensional scaling (NMS)
    - PC ORD – 'Autopilot' mode using Sorensen distances
    - 250 iterations with data, 250 iterations Monte Carlo
    - All snail, salamander and woody plant species found (47 species)
    - Abiotic site characteristics and vegetation variables (n=12 sites)

CORRELATION AMONG GRADIENTS & SITE CHARACTERISTICS

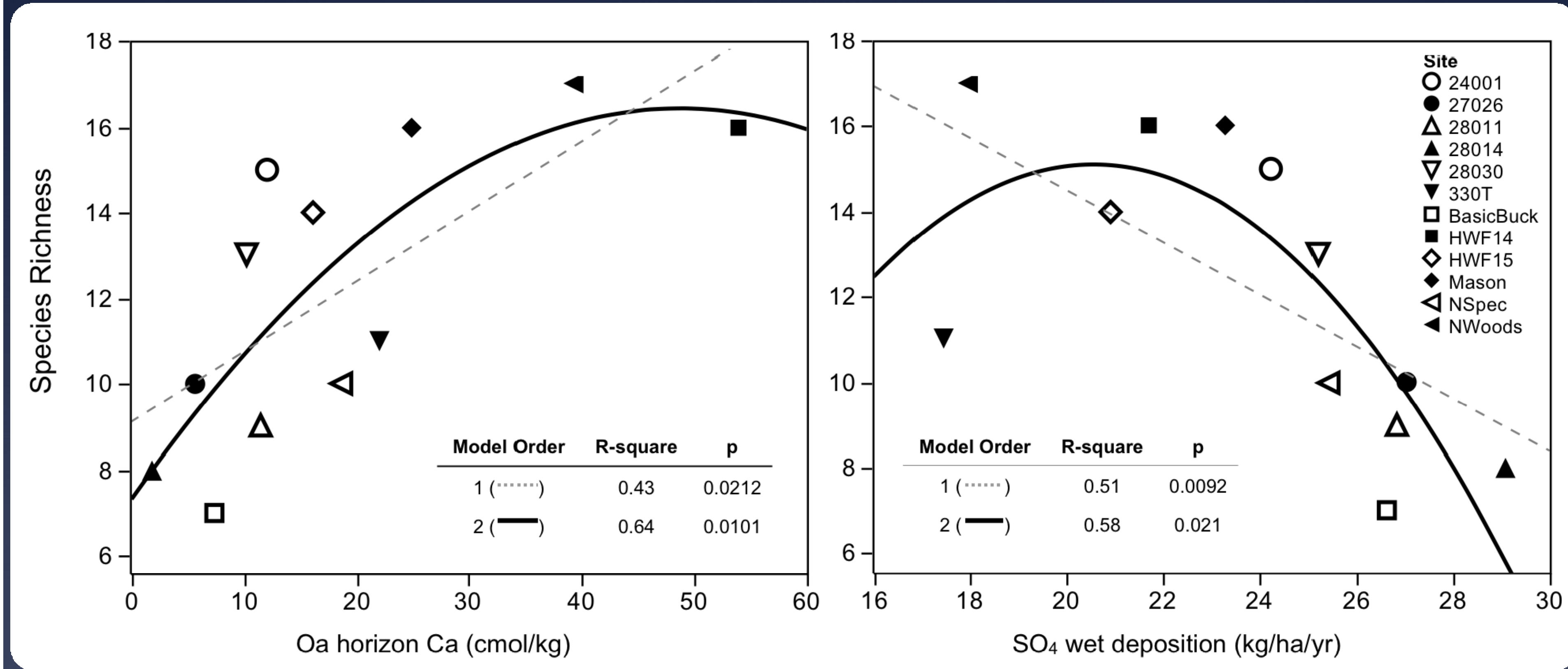
Variable	by Variable	Pearson r	p
Oa calcium	B calcium	0.9283	<.0001
Oa calcium	SO4 wet deposition	-0.6798	0.015
Oa calcium	NO3 wet deposition	-0.7081	0.01
B calcium	NO3 wet deposition	-0.598	0.04
SO4 wet deposition	NO3 wet deposition	0.9664	<.0001
SO4 wet deposition	Elevation	0.7728	0.0032
NO3 wet deposition	Elevation	0.6107	0.0349

- Strong collinearity among soil Ca and deposition; deposition and elevation

Variable	by Variable	Pearson r	p
Oa Ca	total overstory BA	0.7572	0.0043
Oa Ca	% herbaceous cover	0.574	0.05
Oa Ca	CWD % cover	0.7093	0.0098
Oa Ca	Fern % cover	-0.7053	0.0104
SO4 wet deposition	CWD % cover	-0.6522	0.0215
SO4 wet deposition	Fern % cover	0.6222	0.0307
NO3 wet deposition	CWD % cover	-0.7398	0.0059
NO3 wet deposition	Fern % cover	0.6796	0.0151

- Multiple vegetation covariates with soil Ca and acidic deposition

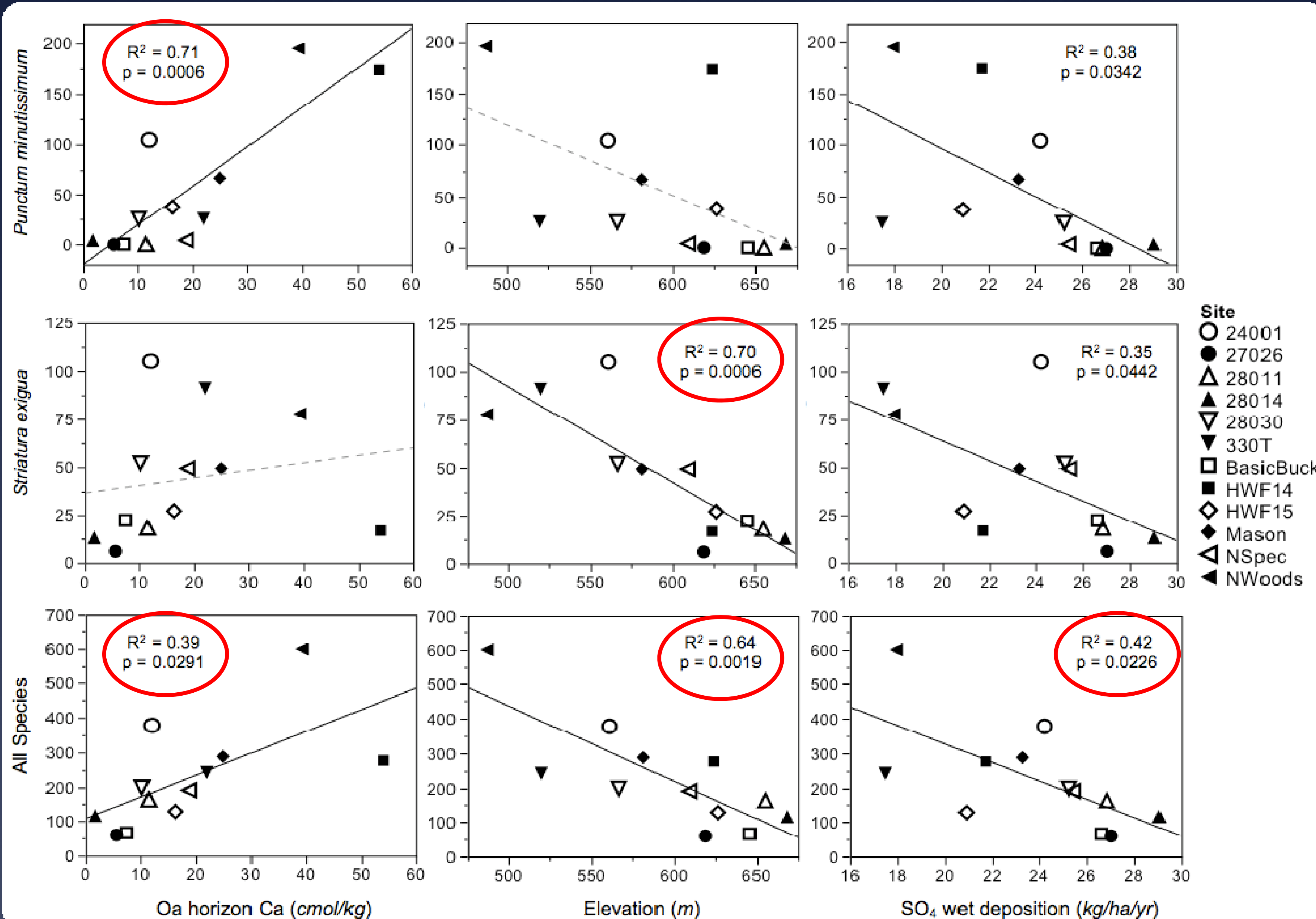
SNAIL SPECIES RICHNESS



SNAIL COMMUNITY COMPOSITION

	Site												
Species	**HWF14**	**NWoods**	**Mason**	**330T**	**Nspec**	**HWF15**	**24001**	**28011**	**28030**	**BasicBuck**	**27026**	**28014**	**Total**
Anguispira alternata	1	0	0	0	0	3	0	3	4	2	1	0	14
Appalachina sayana	1	0	0	0	0	0	2	0	2	0	1	0	6
Cochlicopa morseana	3	13	0	0	0	0	1	0	0	0	0	0	16
Columella simplex	2	4	0	6	0	0	0	0	0	0	0	0	12
Discus catskillensis	5	4	19	1	5	6	5	0	4	1	9	6	65
Euchemotrema fraternum	0	0	0	2	1	4	1	2	2	5	3	0	20
Euconulus fulvus	0	0	2	0	0	0	0	0	0	0	0	0	2
Euconulus polygyratus	8	8	1	0	0	0	1	0	0	0	0	0	18
Gastrocopta pentodon	0	110	0	1	0	0	6	0	0	0	0	0	117
Glyphyalinia rhoadsi	2	5	3	0	0	1	0	0	0	0	0	0	11
Haplotrema concavum	0	0	9	0	1	0	0	1	0	0	0	0	11
Helicodiscus parallelus	0	1	5	0	0	0	0	0	0	0	0	0	6
Helicodiscus shimeki	1	6	2	14	18	7	5	4	1	0	3	6	67
Mesodon thyroidus	0	0	0	0	0	1	0	0	0	0	0	0	1
Mesomphix inornatus	0	0	0	0	0	0	0	0	0	0	2	0	2
Neohelix albolabris	5	4	7	0	2	1	1	0	12	0	0	0	32
Neohelix dentifera	1	1	0	1	0	1	2	0	1	0	0	0	7
Novisuccinea ovalis	0	0	0	0	0	0	0	0	1	0	0	0	1
Paravitrea multidentata	32	14	17	0	0	0	0	0	0	0	0	0	63
Punctum minutissimum	174	195	67	25	4	38	104	0	25	0	0	4	636
Striatura exigua	17	78	49	91	49	27	105	18	52	22	6	13	527
Striatura ferrea	2	1	7	36	11	15	4	5	5	8	1	4	99
Striatura milium	0	101	29	11	24	5	70	1	22	0	0	7	270
Triodopsis tridentata	3	0	4	0	0	3	2	0	0	1	2	1	16
Vertigo gouldi	0	1	0	0	0	0	0	1	0	0	0	0	2
Vitridens ligera	0	0	1	0	0	0	0	0	0	0	0	0	1
Zonitoides arboreus	6	26	39	49	63	12	30	97	44	15	27	63	471
Unknown	12	27	25	5	14	5	39	30	24	12	5	11	209
Total All	275	599	286	242	192	129	378	162	199	66	60	115	2703
Shannon's Index (H)	1.35	1.88	2.18	1.73	1.69	2.06	1.67	0.99	1.90	1.49	1.66	1.37	--
Simpson's Index (D)	2.18	4.84	6.72	4.33	4.26	5.72	4.14	1.78	5.14	3.63	3.46	2.52	--

SNAIL SPECIES RESPONSES TO ABIOTIC GRADIENTS



SNAIL COMMUNITY MODELS

Land Snail Abundance				
Model	**K**	**RSquare**	**AICc**	**ΔAICc**
Elevation, Herbaceous % cover	2	0.81	146.26	--
Oa Ca, Elevation	2	0.78	147.91	1.65
SO4 wet deposition, Herbaceous % cover	2	0.77	148.23	1.96

Species Richness				
Model	**K**	**RSquare**	**AICc**	**ΔAICc**
Oa Ca	1	0.51	63.08	--
Oa Ca, Elevation	2	0.63	64.30	1.22
SO4 wet deposition	1	0.43	64.93	1.85

Simpson's D Diversity				
Model	**K**	**RSquare**	**AICc**	**ΔAICc**
Elevation, [Oa Ca x NO3 wet deposition]	2	0.58	45.38	--
SO4 wet deposition, [Oa Ca x NO3 wet deposition]	2	0.54	46.32	0.94
Elevation, [Oa Ca x SO4 wet deposition]	2	0.49	47.60	2.22

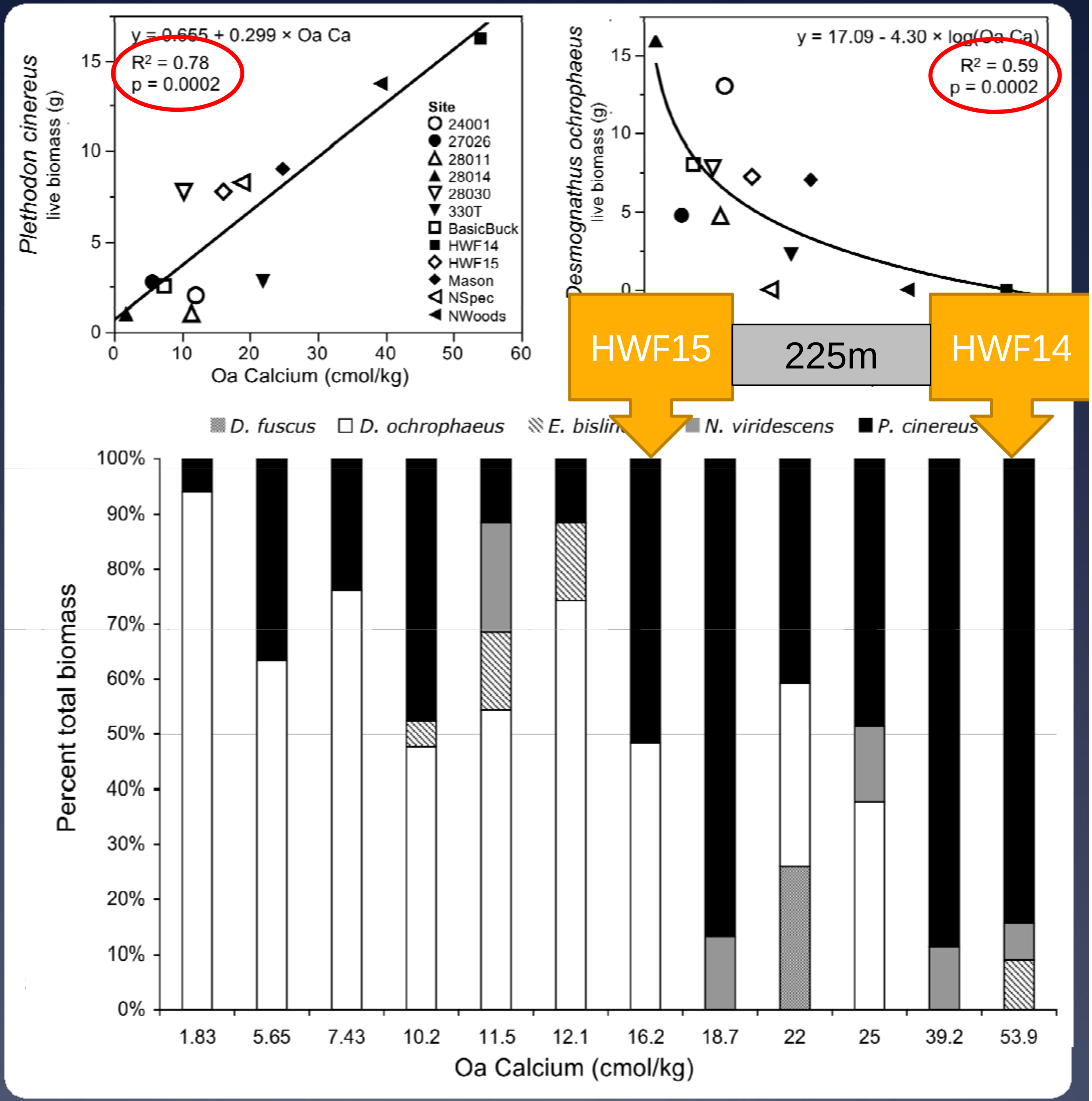
SALAMANDER COMMUNITY STRUCTURE

Red-Backed

Plethodon cinereus

Mountain Dusky

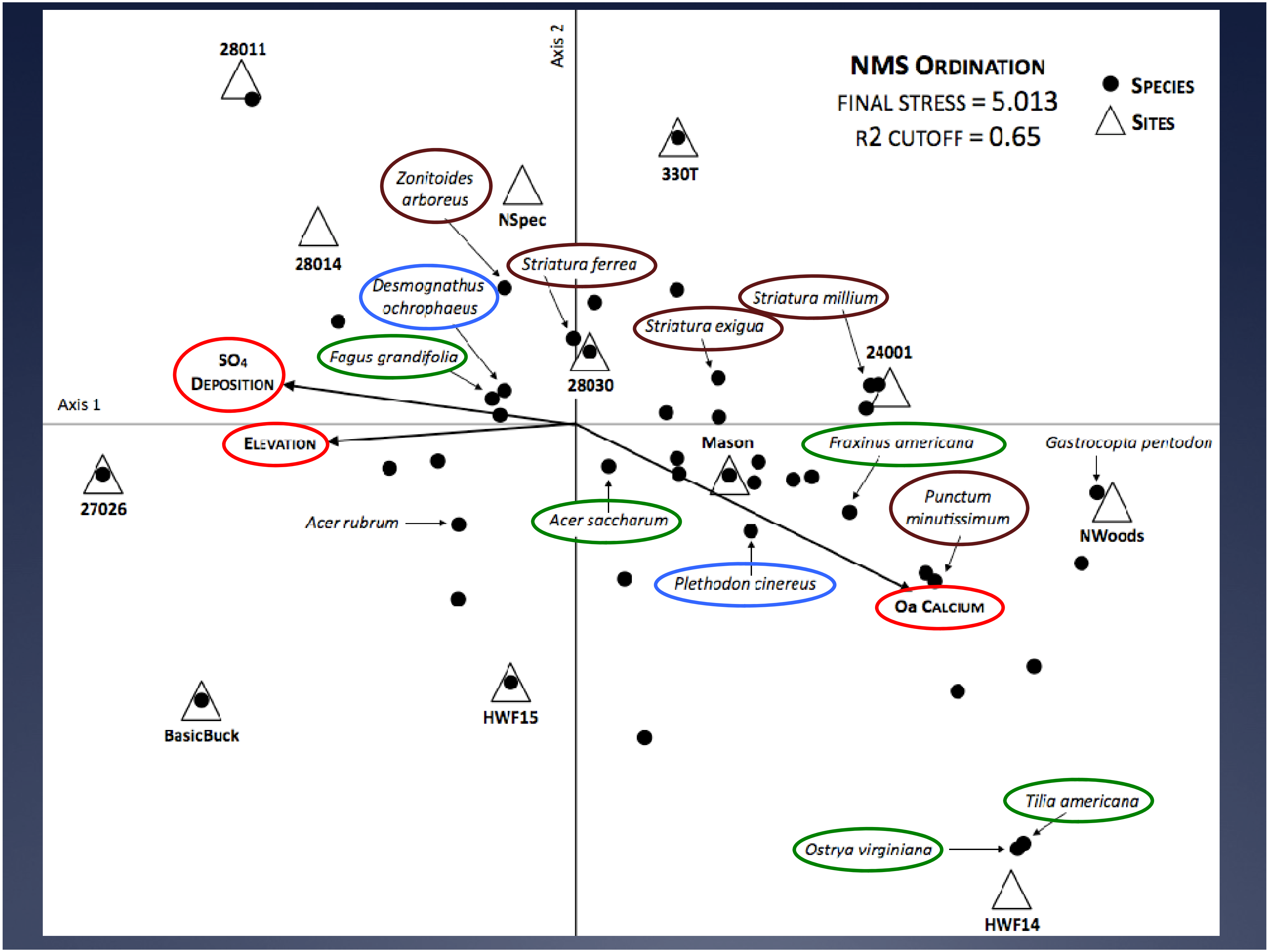
Desmognathus ochrophaeus



SALAMANDER LIVE BIOMASS MODELS

Red Backed Salamanders				
Model variables: Oa Ca, B Ca, mean overstory DBH, total litter snails, total live BA, fern percent cover	***Plethodon cinereus* biomass (g)**			
Model	**R^2**	**RMSE**	**AIC**	**ΔAIC**
Oa Ca, mean overstory DBH, total litter snail abundance	0.9138	1.7498	62.6173	--
Oa Ca	0.7771	2.5165	63.0155	0.3982
Oa Ca, mean overstory DBH	0.8456	2.2072	63.3186	0.7013
Oa Ca, total live BA	0.8166	2.4058	65.386	2.7687
Oa Ca, fern % cover	0.7803	2.6332	67.5538	4.9365

Mountain Dusky Salamanders				
Model variables: Oa Ca, B Ca, tree base percent cover, distance to nearest stream, fern percent cover	***Desmognathus ochrophaeus* biomass (g)**			
Model	**R^2**	**RMSE**	**AIC**	**ΔAIC**
Oa Ca, tree base % cover	0.6915	3.1185	71.613	--
fern % cover, tree base % cover	0.6418	3.3603	73.4051	1.7921
Oa Ca	0.4656	3.8935	73.4901	1.8771
tree base % cover	0.4553	3.931	73.72	2.107
fern % cover	0.3686	4.2323	75.4925	3.8795



NMS Ordination
Final Stress = 5.013
R2 cutoff = 0.65
Species
Sites
Axis 1
Axis 2
28011
330T
NSpec
28014
Zonitoides arboreus
Striatura ferrea
Desmognathus ochrophaeus
Striatura millium
Striatura exigua
SO4 Deposition
Fagus grandifolia
28030
24001
Elevation
Mason
Fraxinus americana
Gastrocopta pentodon
27026
Acer rubrum
Acer saccharum
Punctum minutissimum
NWoods
Plethodon cinereus
Oa Calcium
BasicBuck
HWF15
Tilia americana
Ostrya virginiana
HWF14

CONCLUSIONS AND NEXT STEPS

- Abundance, diversity and structure of snail communities is highly sensitive to interactions among soil Ca, elevation, acidic deposition and herbaceous cover

- Community structure of salamanders shifted along the Ca gradient

- Red-backed salamanders – a keystone species in soil processes and forest floor food webs – live biomass increased very strongly with the Ca gradient

- Several snail and plant taxa found only at the 2-3 highest Ca sites – suggests the existence of a 'calciphilic' species assemblage and the potential for 'neorefugia'

- Maintenance of biodiversity may support forest ecosystem resilience to change

- Summer 2010: sampling of soil arthropods and salamander diets along gradient
- New work on Adirondack songbird communities (starting Fall 2010)
- New funding to expand geographical range of study to Northern Forest

THANKS

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QUESTIONS?

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College of Environmental Science and Forestry