The Battle for Suburbia

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Cary Institute for Ecosystem Studies
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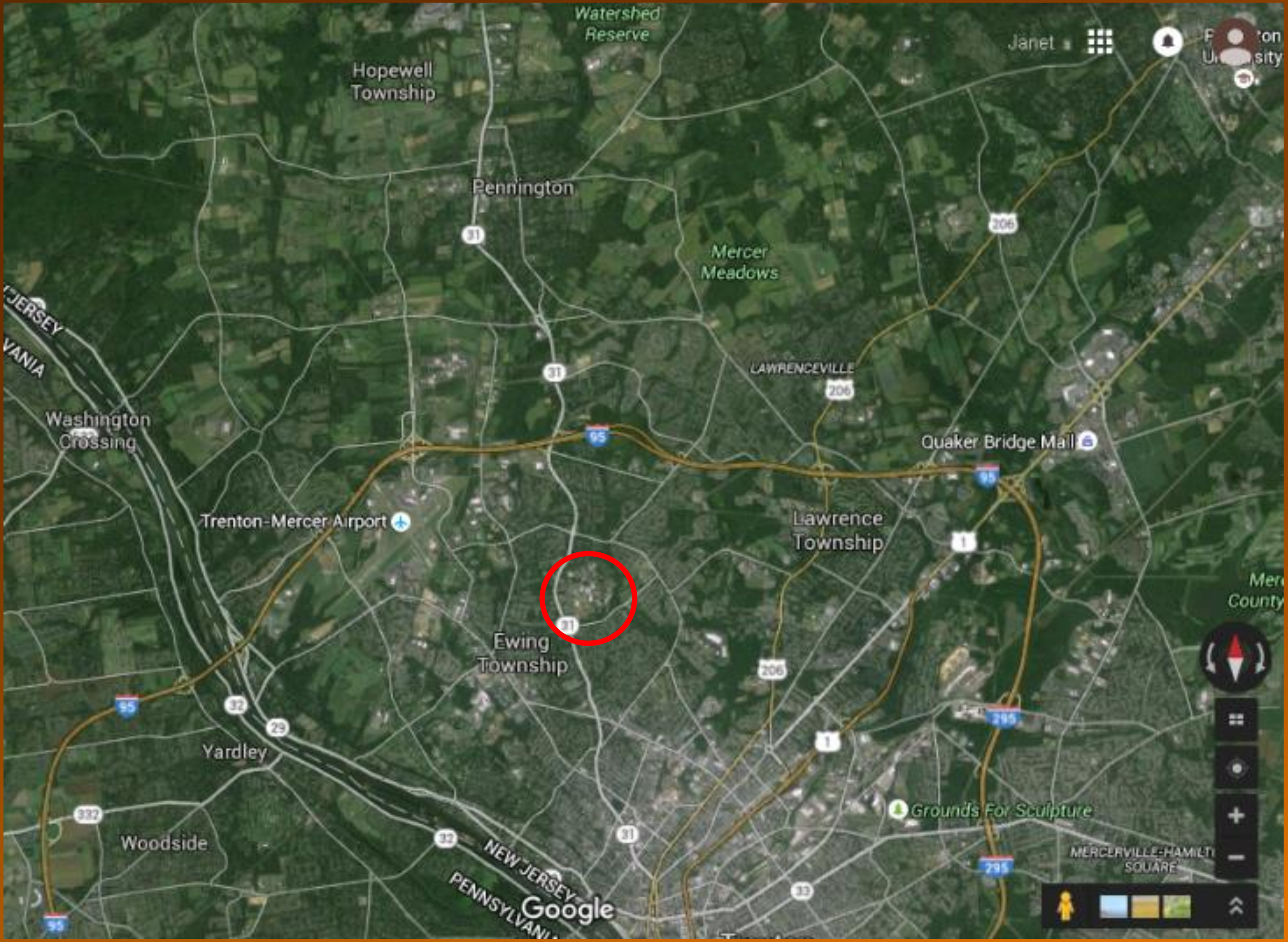
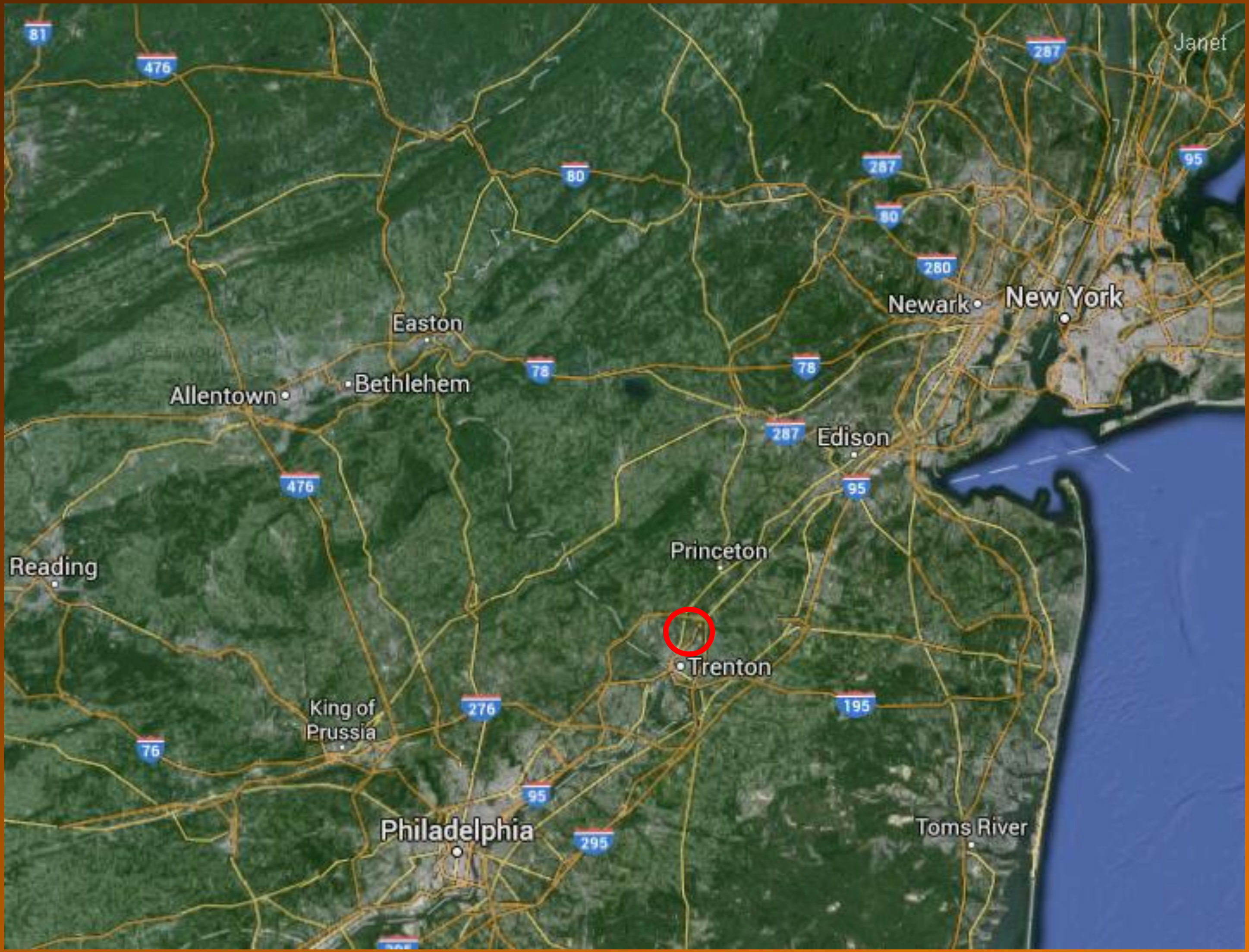


The College of New Jersey



metropolitan forests

REVIEWS REVIEWS REVIEWS

Filling key gaps in population and community ecology

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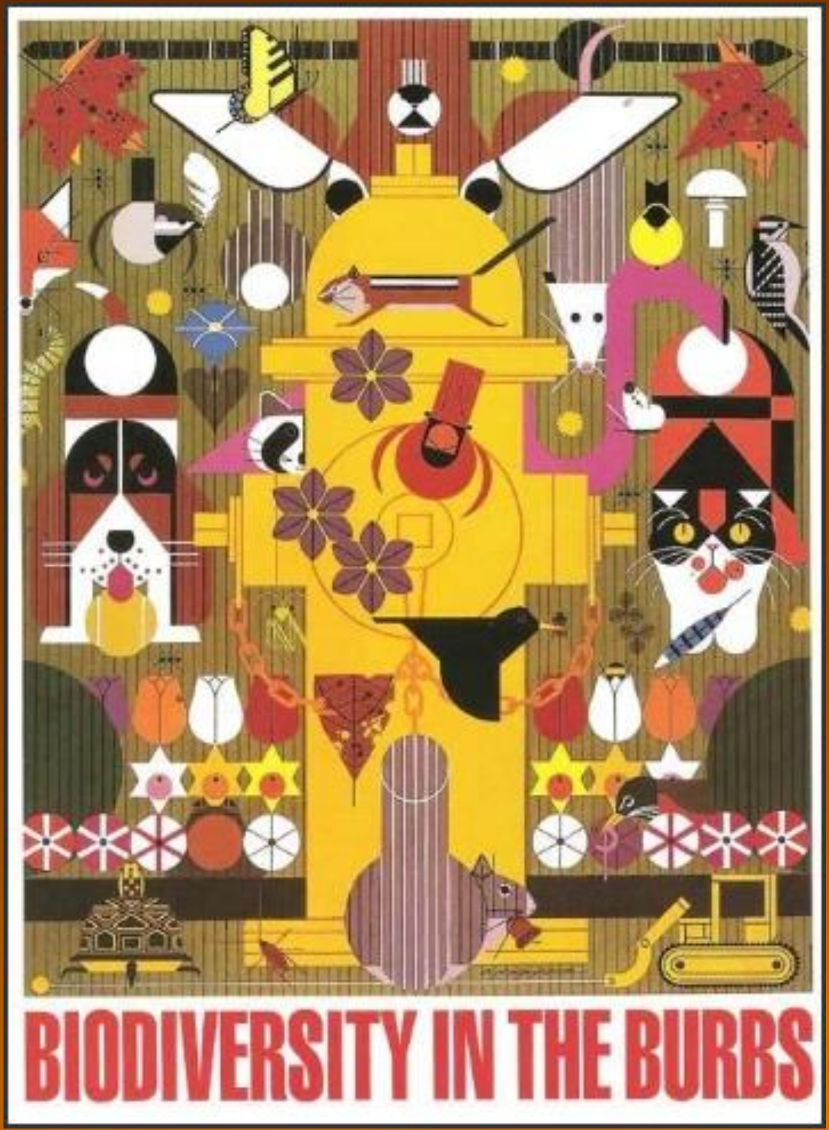
We propose research to fill key gaps in the areas of population and community ecology, based on a National Science Foundation workshop identifying funding priorities for the next 5–10 years. Our vision for the near future of ecology focuses on three core areas: predicting the strength and context-dependence of species interactions across multiple scales; identifying the importance of feedbacks from individual interactions to ecosystem dynamics; and linking pattern with process to understand species coexistence. We outline a combination of theory development and explicit, realistic tests of hypotheses needed to advance population and community ecology.

Front Ecol Environ 2007; 5(3): 145–152

“ **The semi-natural matrix --** Ecological studies often investigate pristine systems, but many organisms now persist in the fringes of habitat around highly disturbed areas (Brauer and Geber 2002). Although much work has been conducted in some of these areas (eg eastern North American old-fields, much of Europe) and despite a growing interest in urban ecology, the semi-natural matrix is still mainly unexplored, its ubiquity notwithstanding.”

metropolitan forests



Charley Harper

metropolitan forests

invasive, non-native plants

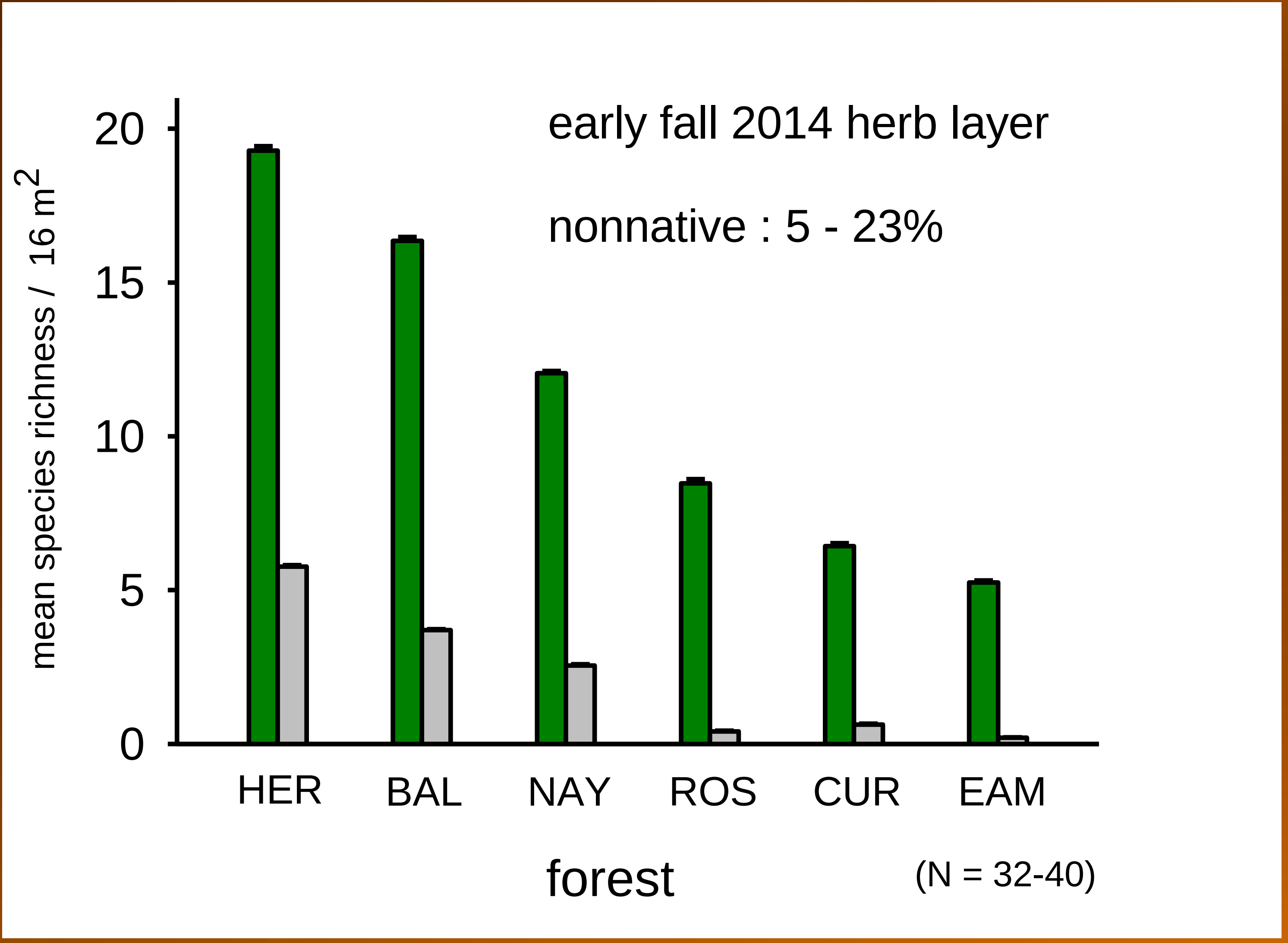
in metro forests:

- nearby seed sources
- high disturbance rate
- fragmented habitat; increased edge
- multiple, co-occurring species

invasive, non-native plants

ecological advantage over native plants

- super-competitors
- enemy release
- exploitation of empty niches
- multiple species – 'invasional meltdown'

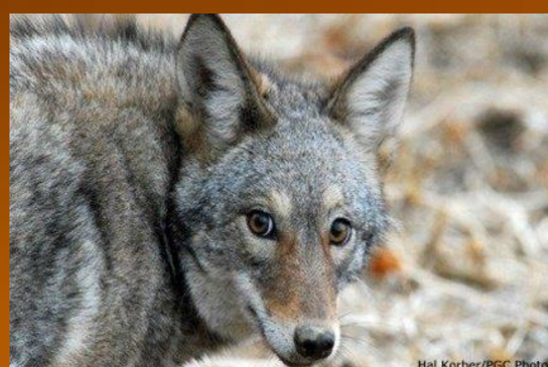

early fall 2014 herb layer
nonnative : 5 - 23%
mean species richness / 16 m2
20
15
10
5
0
HER
BAL
NAY
ROS
CUR
EAM
forest
(N = 32-40)

overabundant deer

Princeton, NJ:
45 deer / km^2

Hopewell, NJ:
32 deer / km^2

overabundant deer



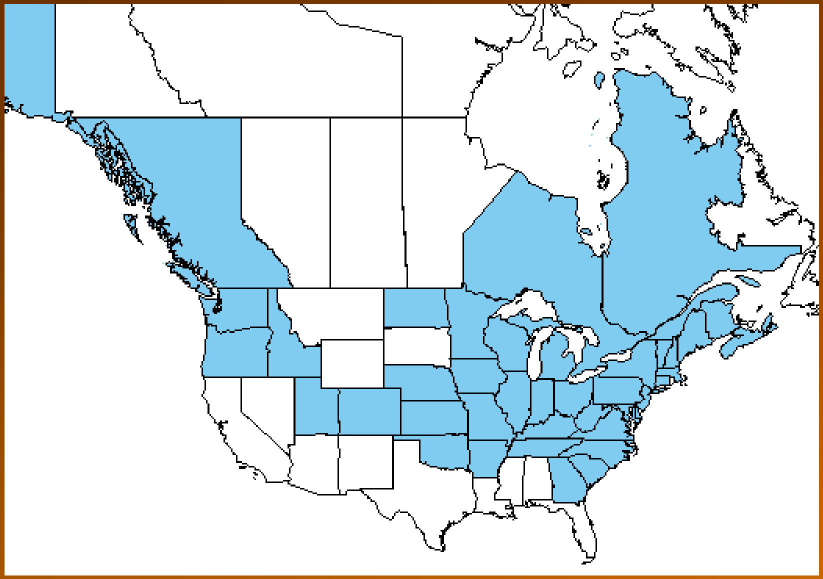
overabundant deer

metropolitan forests

main research questions

- How do deer & invasive plant species contribute to community structure of herb layer plant communities within metro forests ?
- How do co-occurring invasive plants interact – competition, facilitation – invasional meltdown?
- Are plant invaders passengers on the ecosystem change wrought by overabundant deer or are they drivers, causing plant community decline?
- How to tackle these relatively large questions in the context of teaching at an undergraduate college.

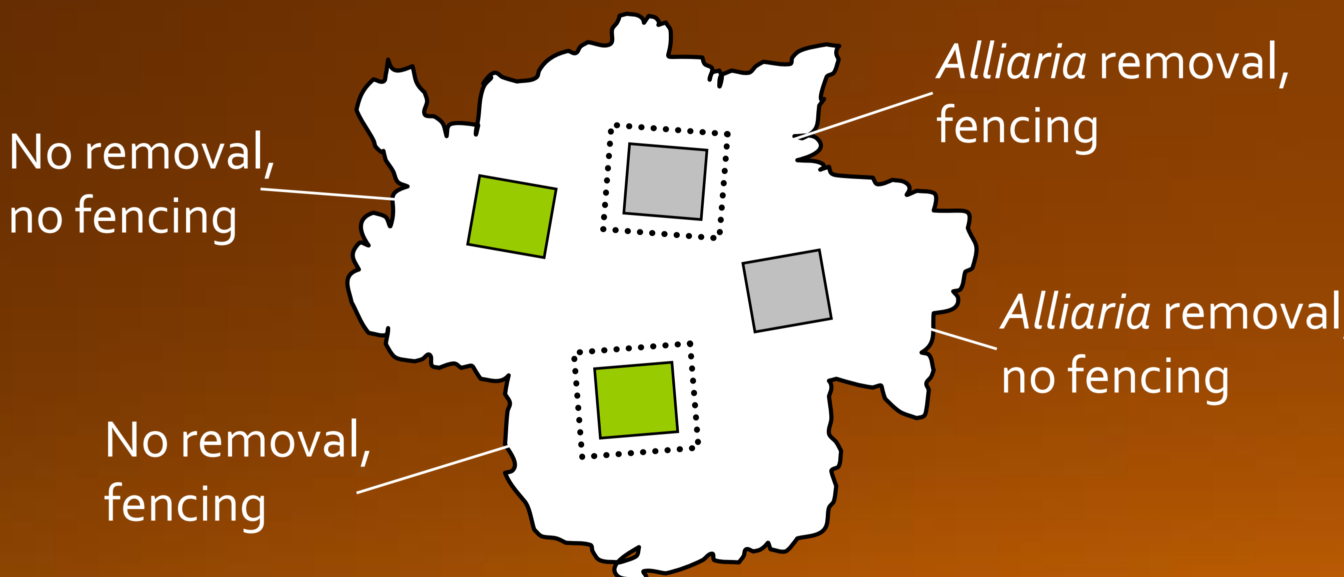
Alliaria petiolata, garlic mustard



Alliaria stand, Westchester County

Alliaria removal x deer exclosure

3 forests ; 8 stands of *Alliaria* ; 4 treatments / stand, 4 m^2 plots:



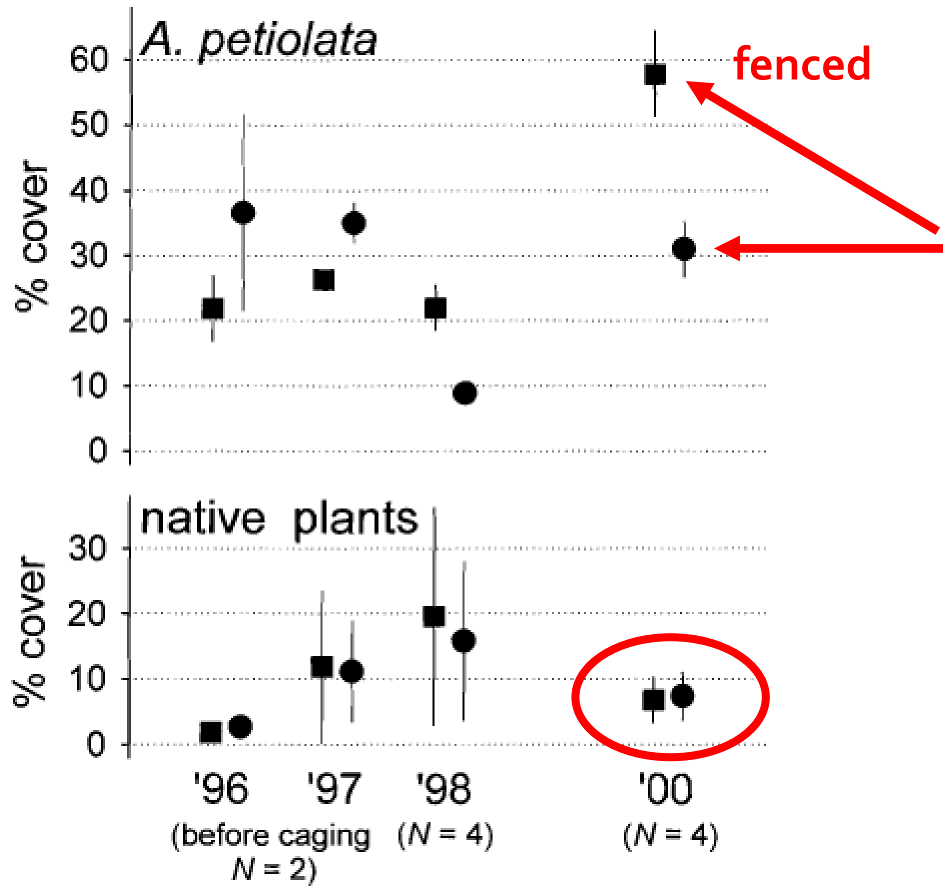


Figure 1. Mt. Holly Sanctuary: estimated percent cover (mean ± *SE*; small error bars are hidden by the symbol) in 4-m² plots that were caged to prevent herbivory (squares) or uncaged (circles).

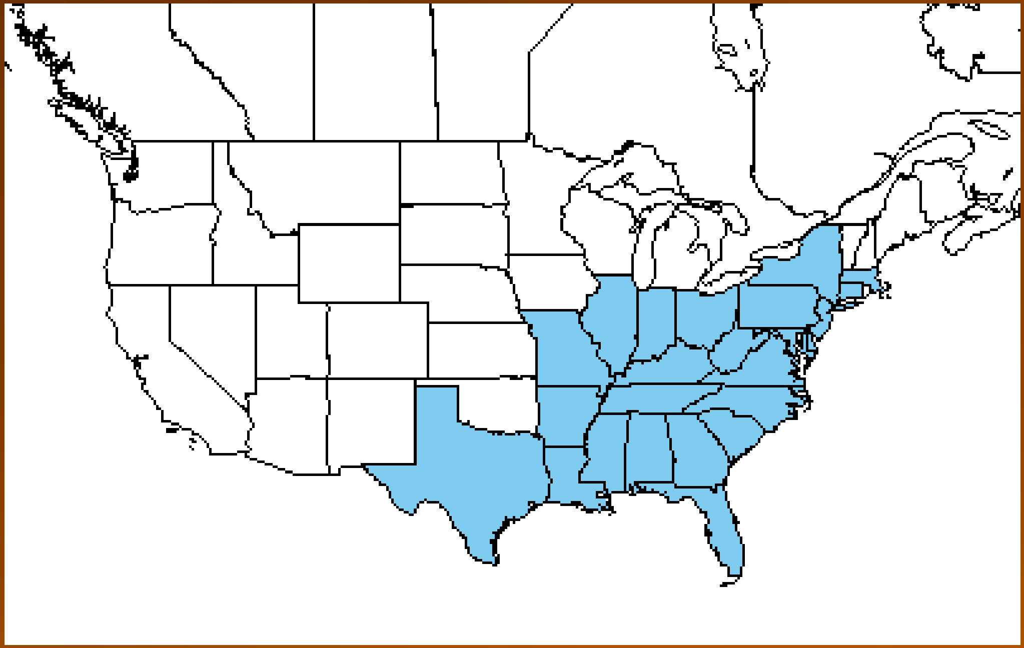
Morrison and Brown 2004

Alliaria response to deer exclosure


no fencing


fencing

Microstegium vimineum
Japanese stilt-grass



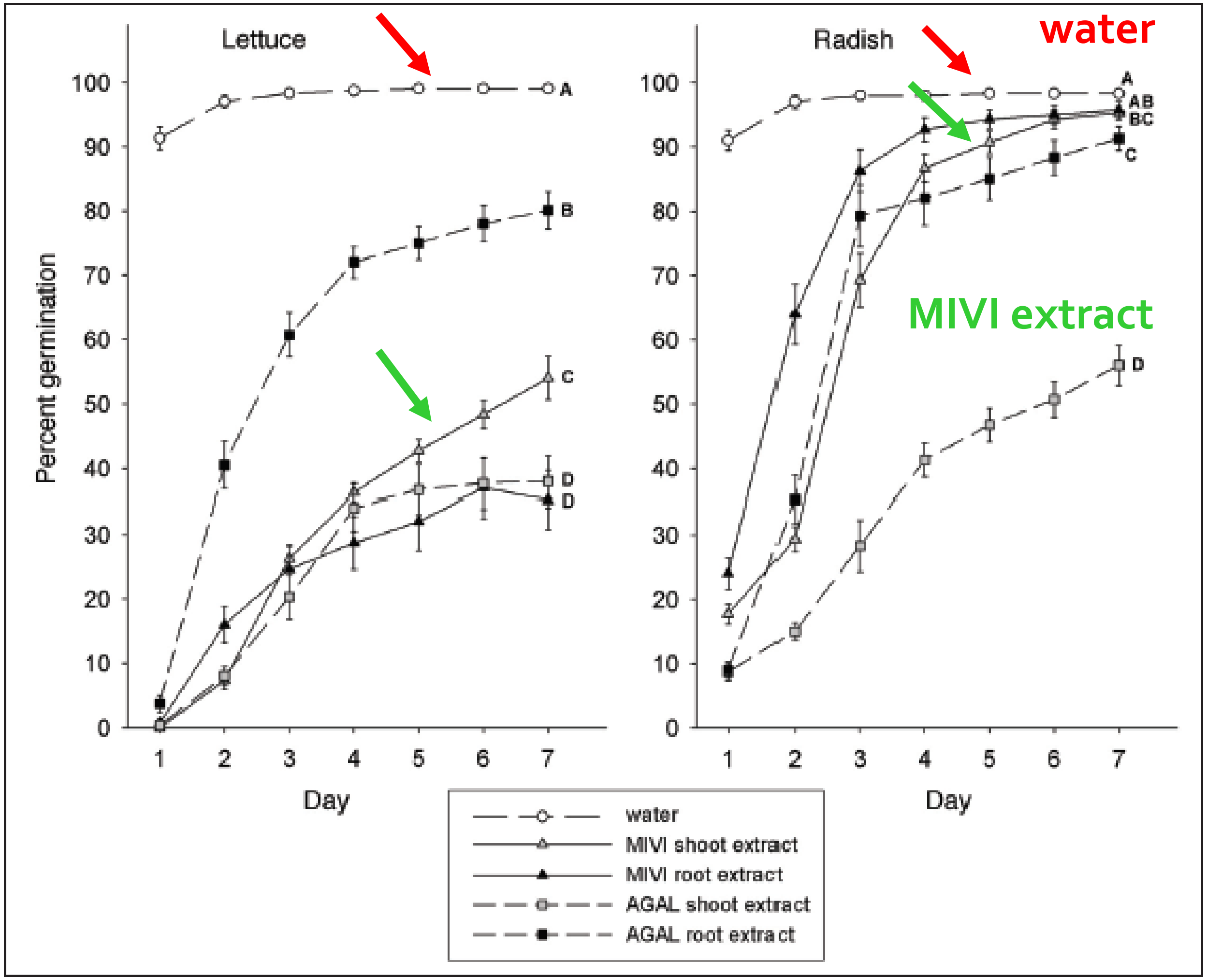


Figure 1. Percent germination (means ± SE, $n = 12$) of Lettuce and Radish seeds exposed over seven days to water or aqueous extracts from shoots or roots of Japanese Stilt-grass (non-native, invasive) or White Snakeroot (native). Day 7 values with different letters are significantly different (based on post-hoc Fisher's LSD tests; ANOVAs on Day 7 data, EXTRACT effect: Lettuce, $F = 106.64$, df = 4,40, $P < 0.0001$; Radish, $F = 57.49$, df = 4,40, $P < 0.0001$).

Corbett and Morrison 2012

co-invasive species

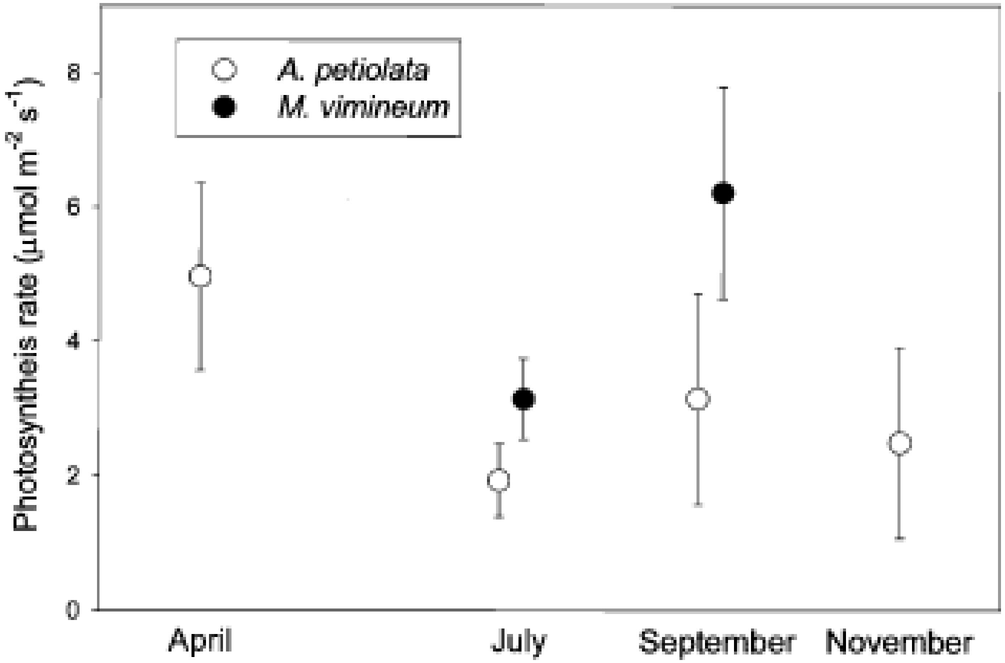
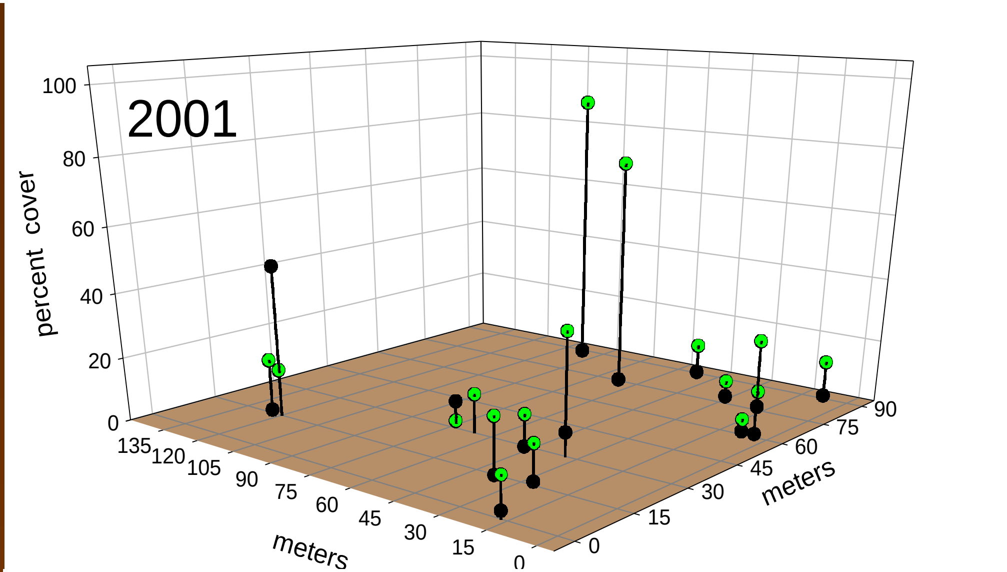
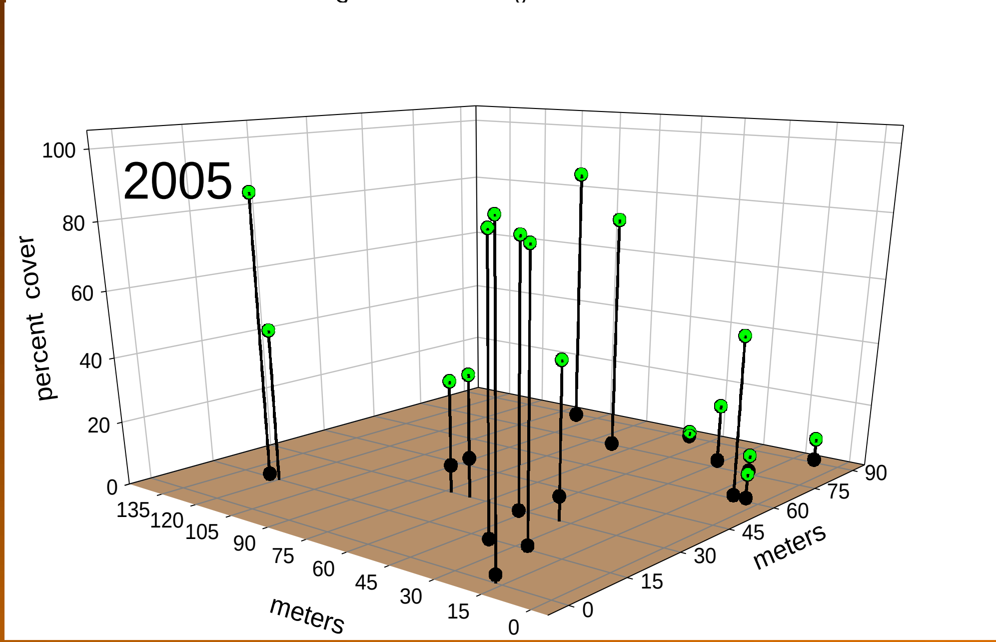


FIG. 7. In situ photosynthesis rates (µmol·m^{-2}·s^{-1}) of *Alliaria petiolata* and *Microstegium vimineum* in 2002 in the forest at Washington Crossing State Park, Titusville, NJ. No data are shown for *M. vimineum* in April and November because of their shorter vegetative phase (means ± 95% CL; *n* from left to right: 23, 27, 36, 16, 24, 16).

Morrison et al. 2007

• *Alliaria petiolata* • *Microstegium vimineum*





Morrison et al. 2007

deer pressure in metro forest study sites

measurement requirements :

- site-specific for experimentation purposes
- ease and rapidity of measurement, allowing high replication in a fragmented landscape
- very low cost
- visitor-proof

<u>Three methods</u>

- pellet plots (fecal accum. rate)
- forest “secchi” boards (shrub cover)
- woody browse signs

pellet plots

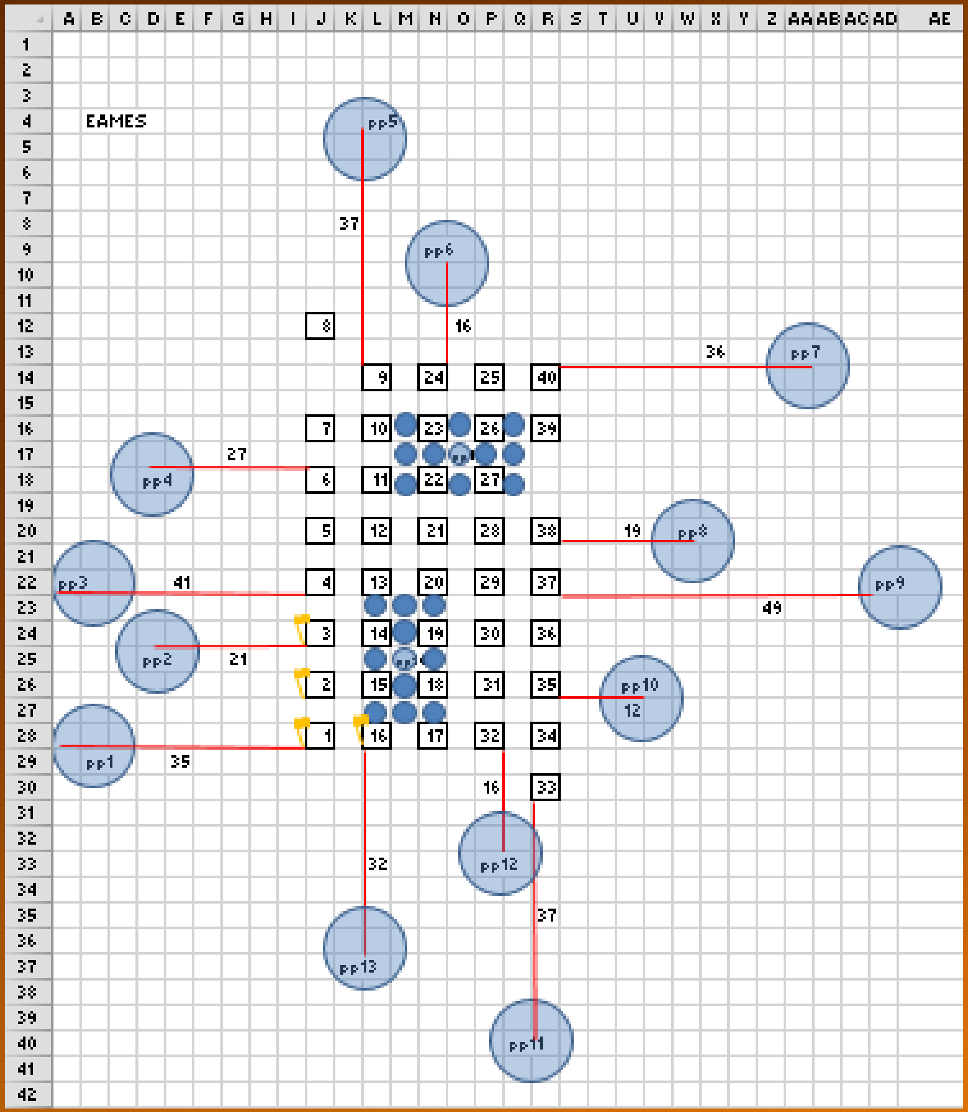
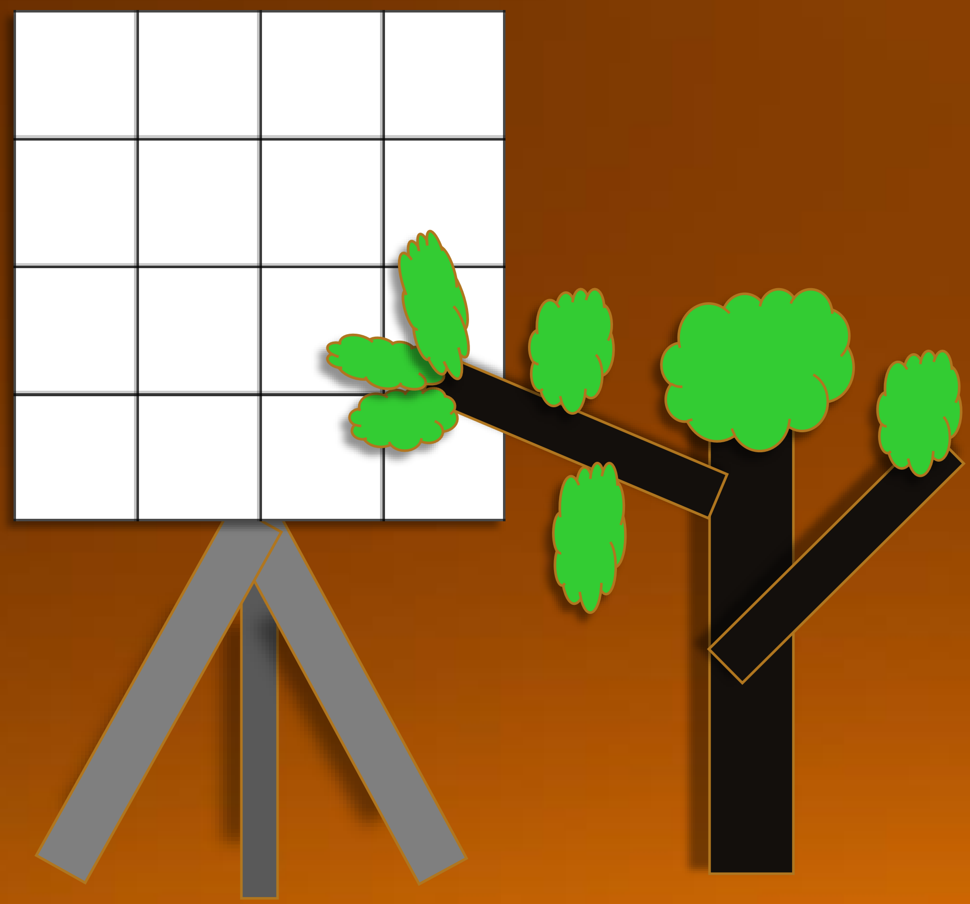


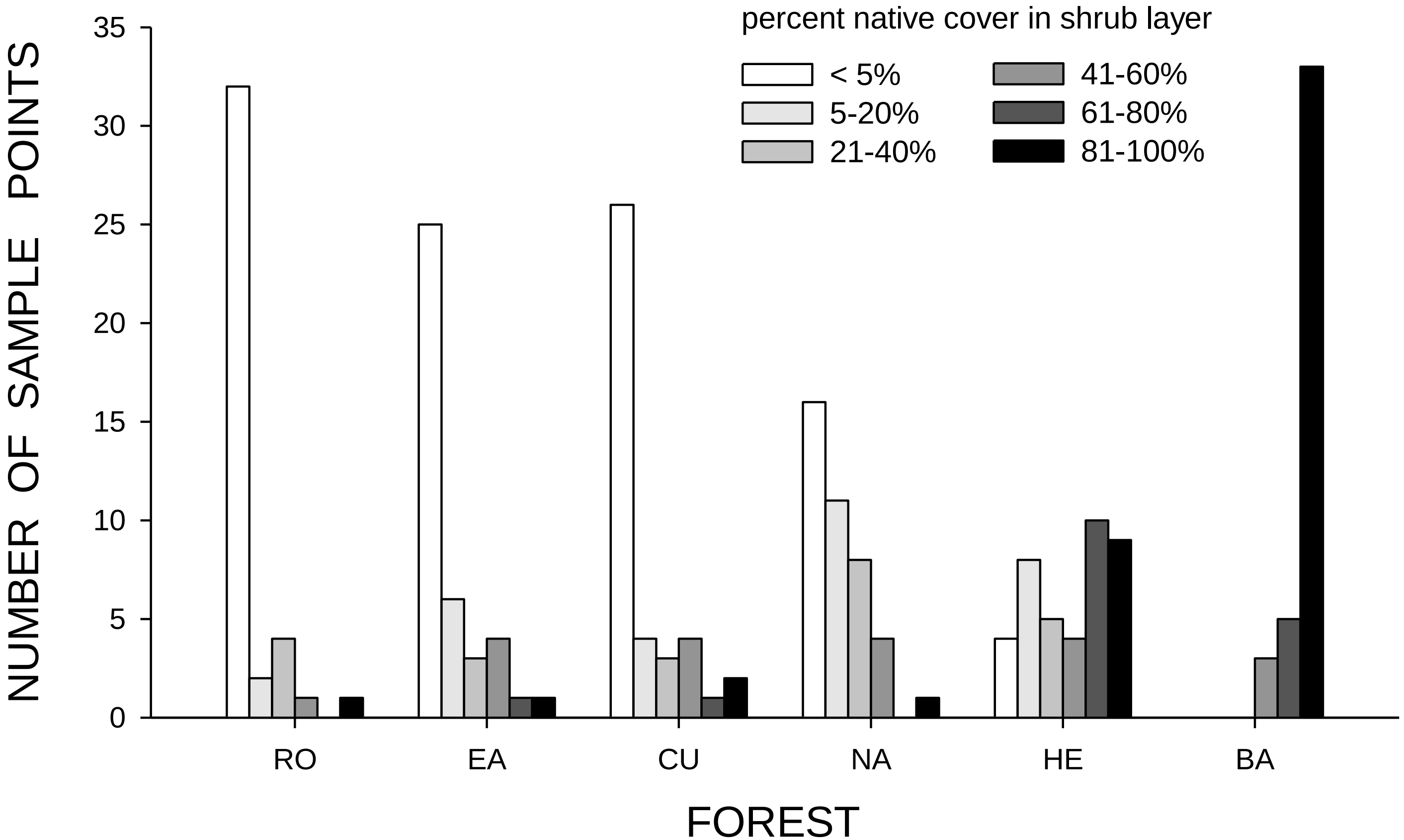
Table 1. Deer fecal pellet groups found in 1,680 m^2 per forest in six forest stands in central New Jersey, and deer densities estimated from accumulated pellet groups over time and two defecation rate estimates.

	standing crop pellet groups March 2010	Δt days elapsed between pellet surveys (March – October)	P accumulated pellet groups October 2010	deer/km^2 low estimate	deer/km^2 high estimate
Rosedale	70	208	7	0.54	0.85
Eames	18	205	69	5.42	8.53
Curlis	5	206	3	0.23	0.37
Nayfield	3	205	12	0.94	1.48
Herronton	52	201	22	1.76	2.77
Baldpate	38	216	46	3.43	5.39

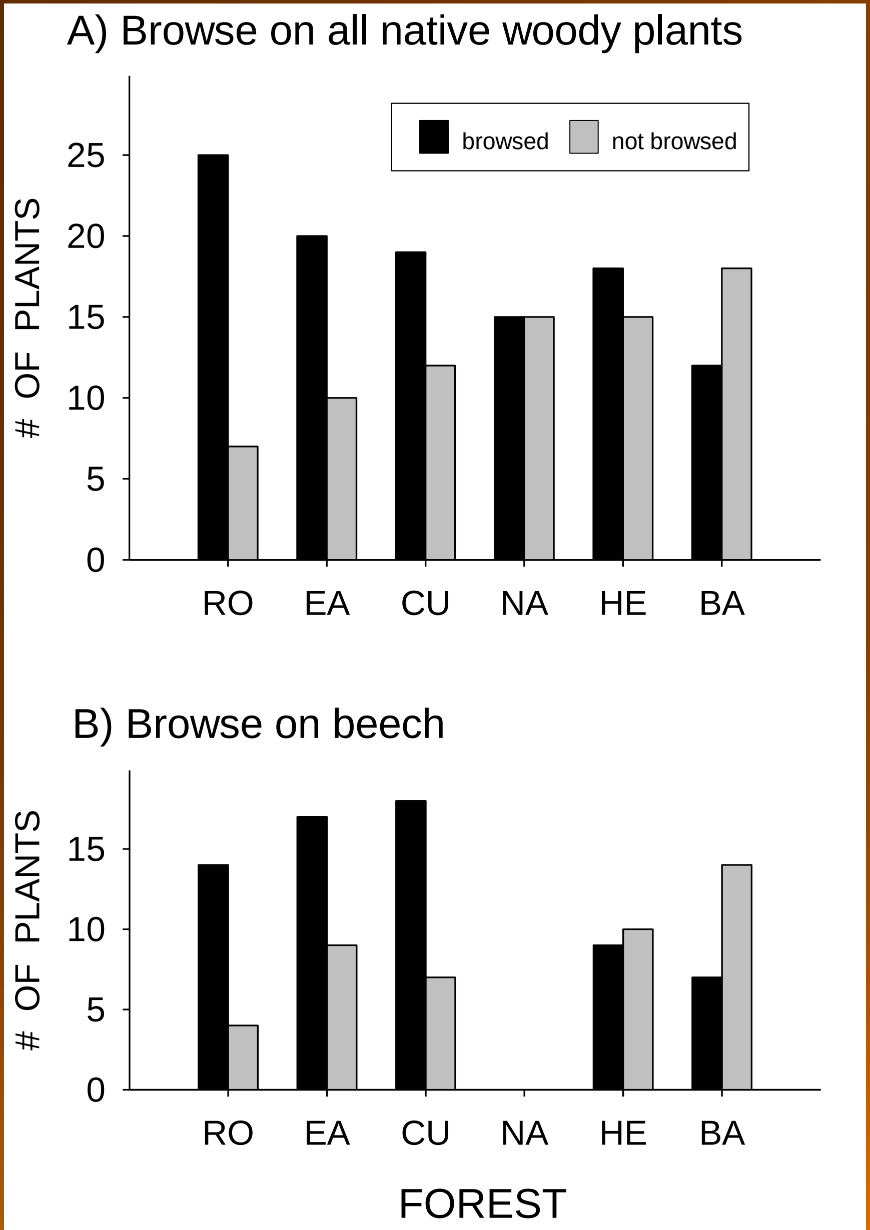
forest "secchi"



from Dr. Michael Van Clef, Friends of Hopewell Valley Open Space


percent native cover in shrub layer
< 5%
5-20%
21-40%
41-60%
61-80%
81-100%
NUMBER OF SAMPLE POINTS
0
5
10
15
20
25
30
35
RO
EA
CU
NA
HE
BA
FOREST

woody browse on natives



A) Browse on all native woody plants
browsed
not browsed
OF PLANTS
25
20
15
10
5
0
RO
EA
CU
NA
HE
BA
B) Browse on beech
OF PLANTS
15
10
5
0
RO
EA
CU
NA
HE
BA
FOREST

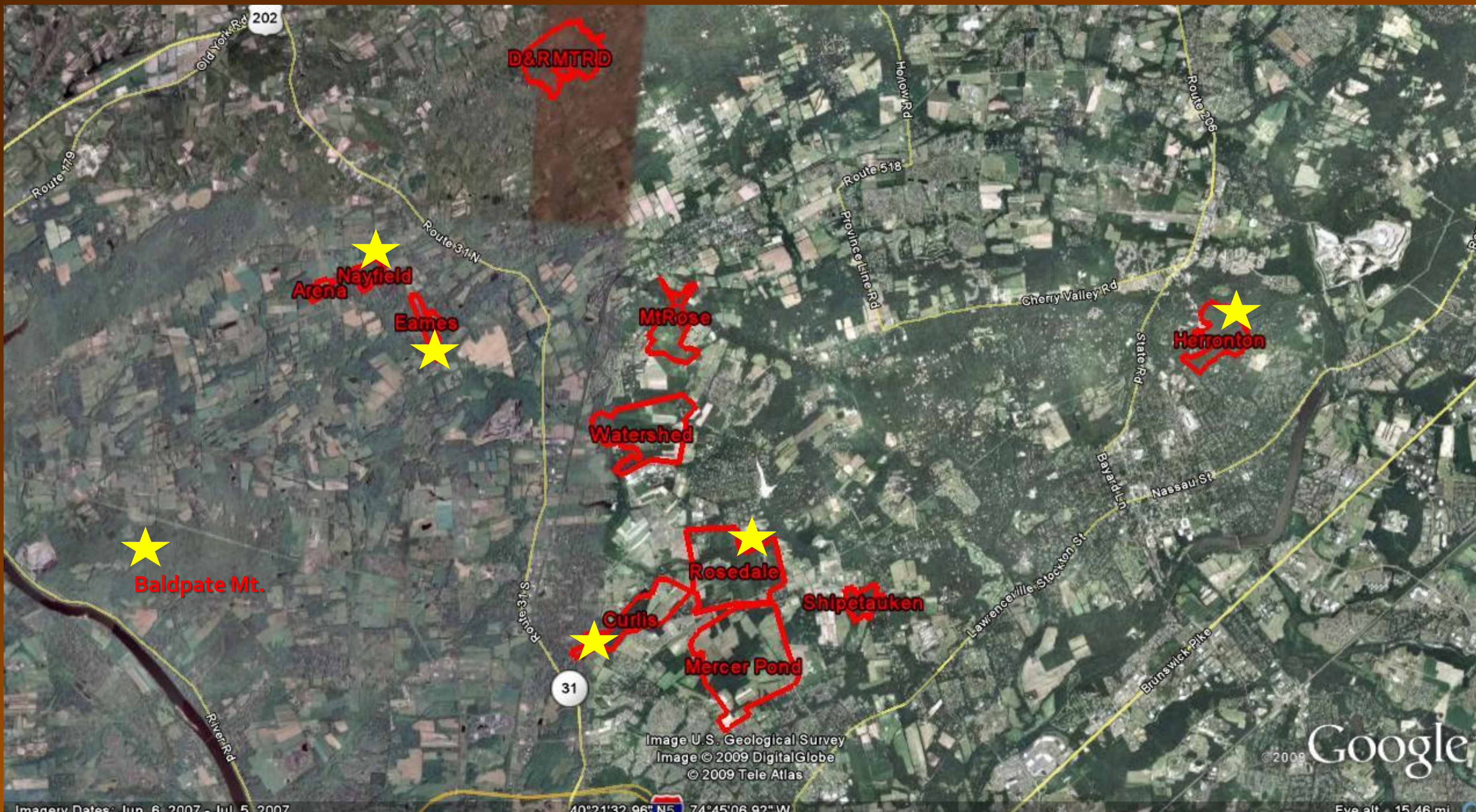
the deer–mivi–alpe experiment

choosing the study forests (2010, 20 surveyed)

- ALPE and MIVI present
- ALPE- and MIVI-free areas for the experiment
- similar age, canopy diversity, soils, slope
- range of deer pressure
- permission for long-term plots, fences, and

staged invasions

the six study forests



plots

(2011)

16 m^2

40 / forest

herb layer sampling

- 2012, pre-treatment; late spring, early fall

- 16 ¼ m^2 quadrats/plot

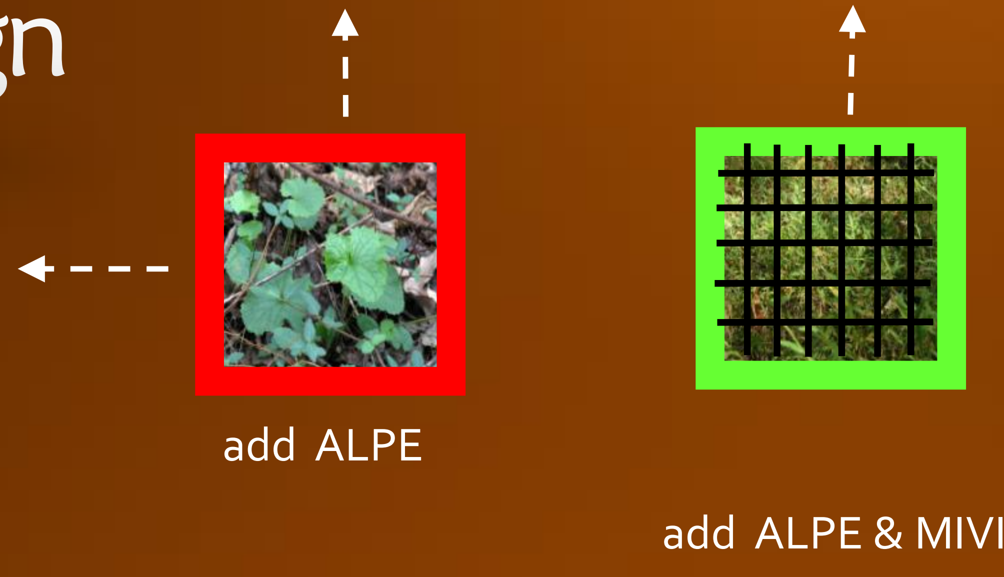
- Score cover of each species in 10% intervals

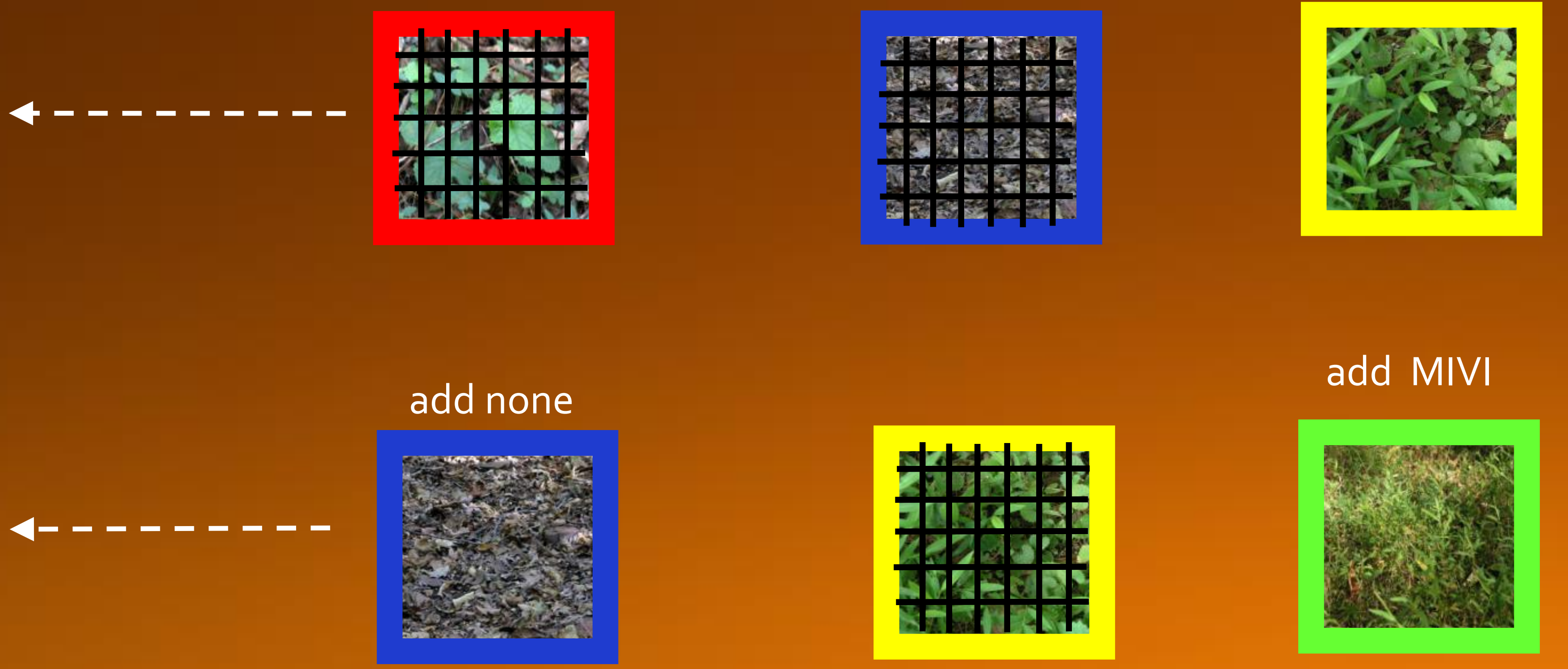
- Convert to interval midpoints, average across the 16 quadrats

hurricane Sandy

experimental design

- 6 forests: 3 lower & 3 higher deer pressure
- 8 treatments
- 5 replicates/treatment/forest
- 16 m² plots
- ~ 40 plots per forest





seeds

- collected mature seed
- 10 local populations of MIVI and ALPE
- pooled populations
- November 2012: added to plots to stratify in situ

fences

installed
March 2013

data collection

semi-annually: herb layer census

annually:

- ALPE, MIVI counts & browse
- shrub layer cover: native, non-native
- woody plant browse and heights
- PAR, leaf litter mass

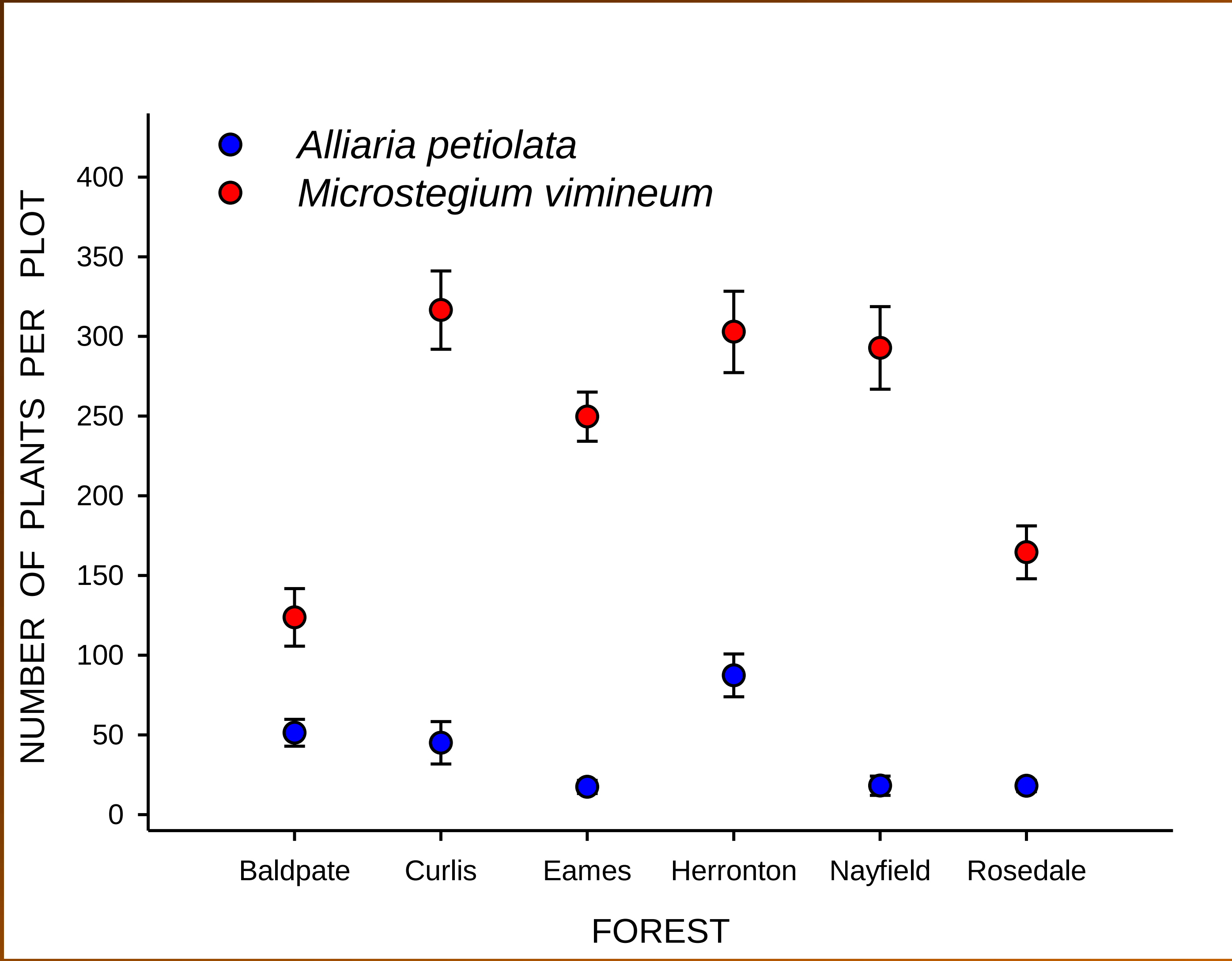
other:

earthworm abundance & diversity

soil water potential, soil compaction

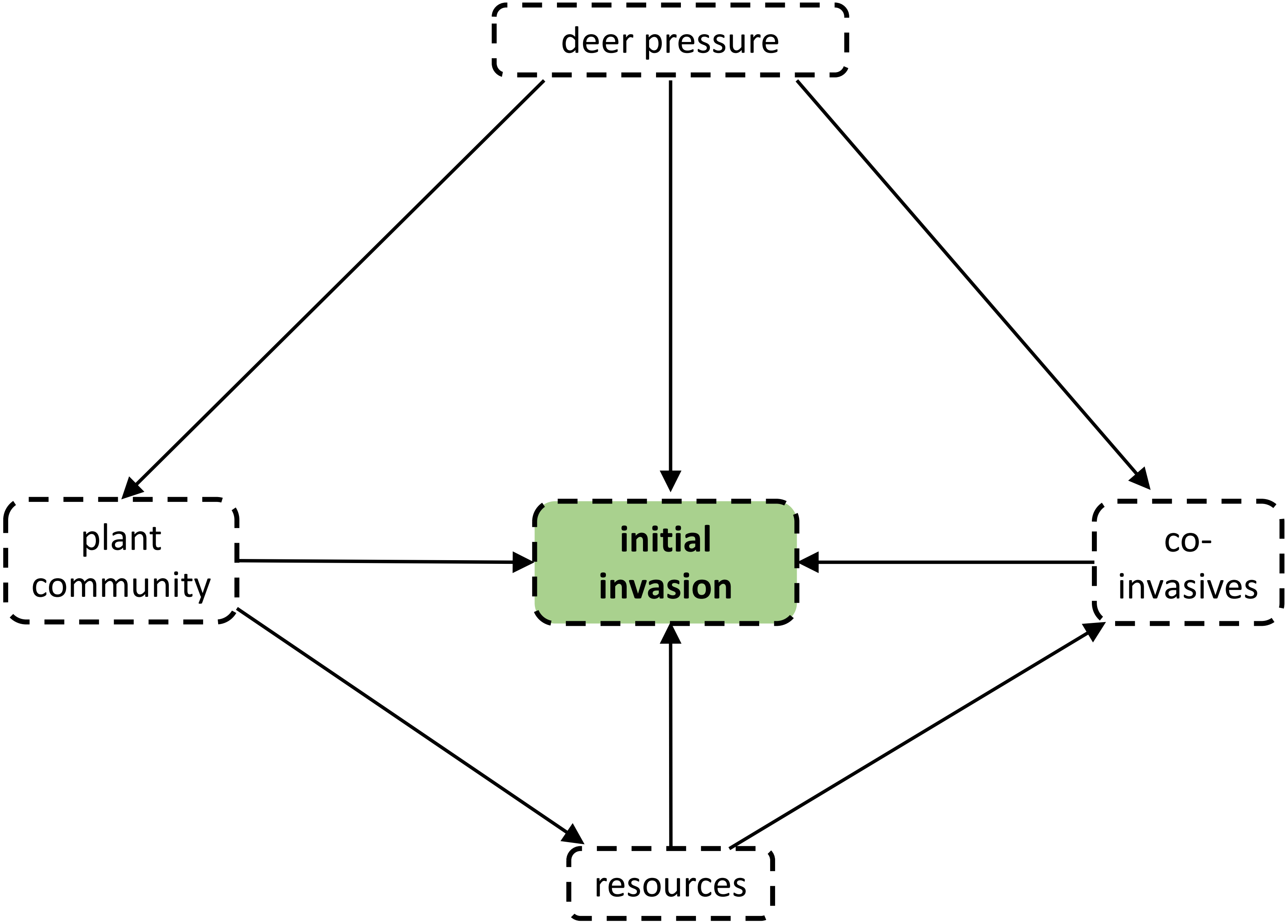
PLFA, basic soil variables (subset of plots)

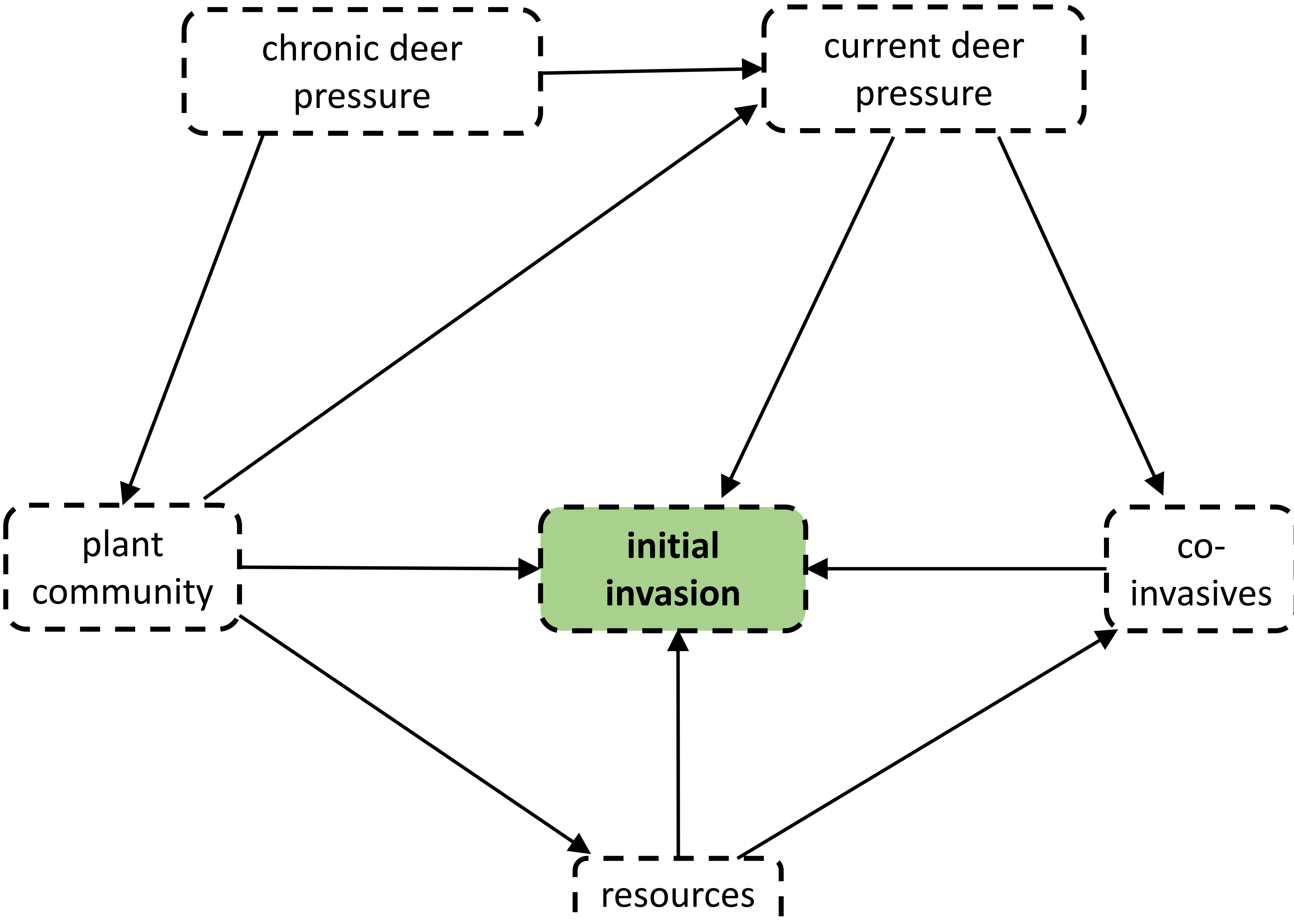
canopy gap

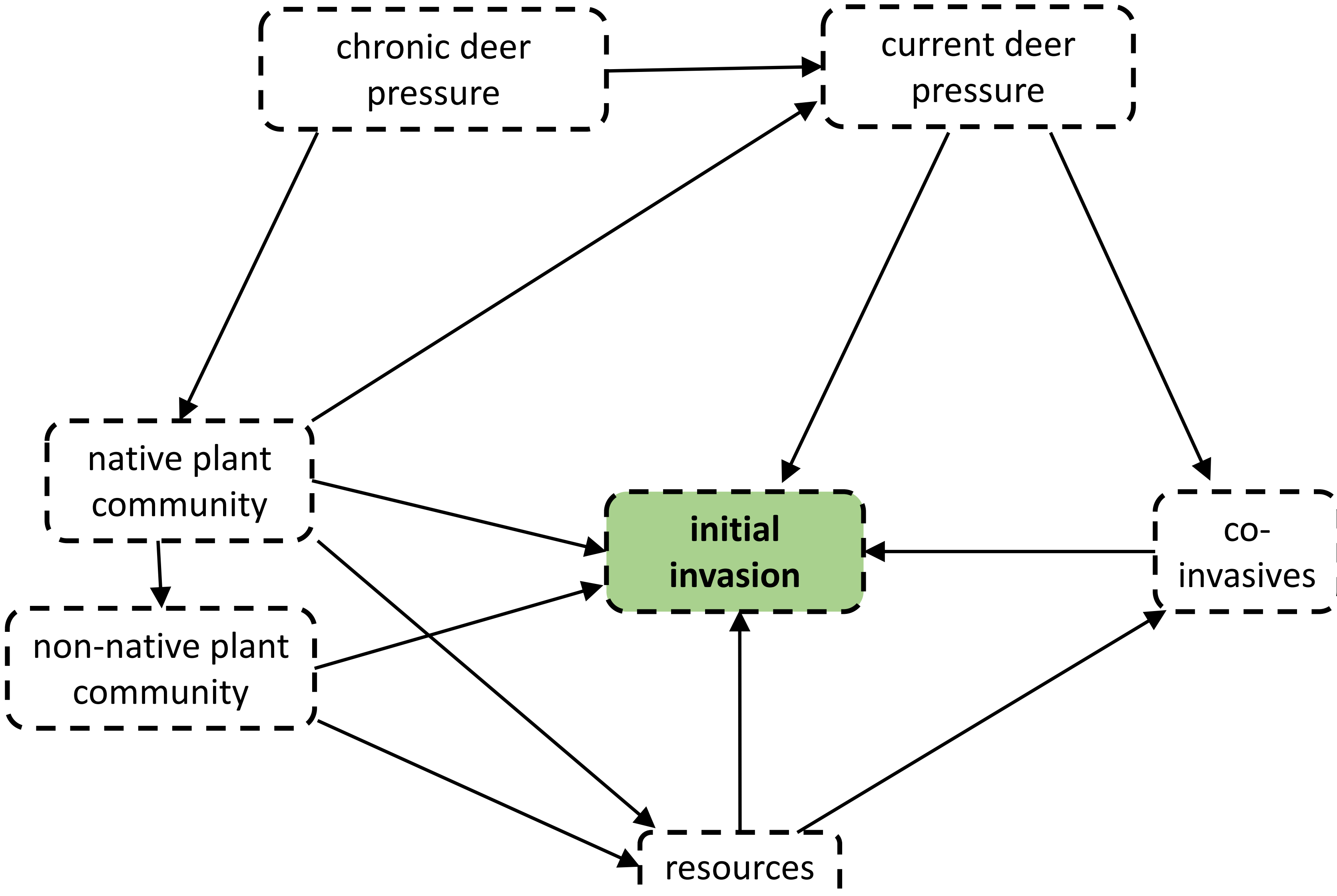


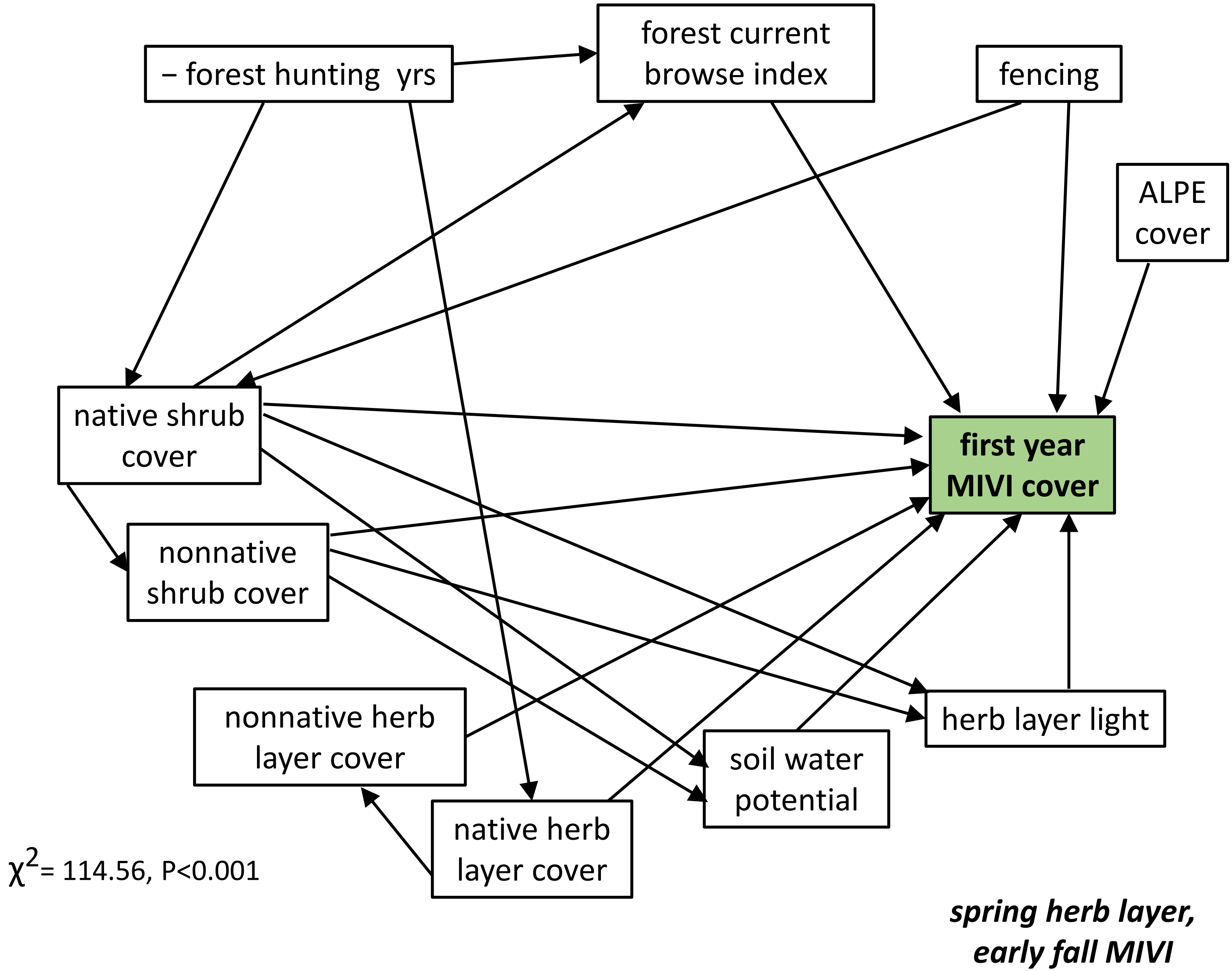
Mean (± SE) plants per plot in each forest, for both *A. petiolata* and *M. vimineum*. Recruitment of both species varied significantly among the forests [ANOVA: ALPE, $F_{(5, 104)}$=9.45, P<0.0001; MIVI, $F_{(5, 101)}$=13.04, P<0.0001].

stiltgrass invasion

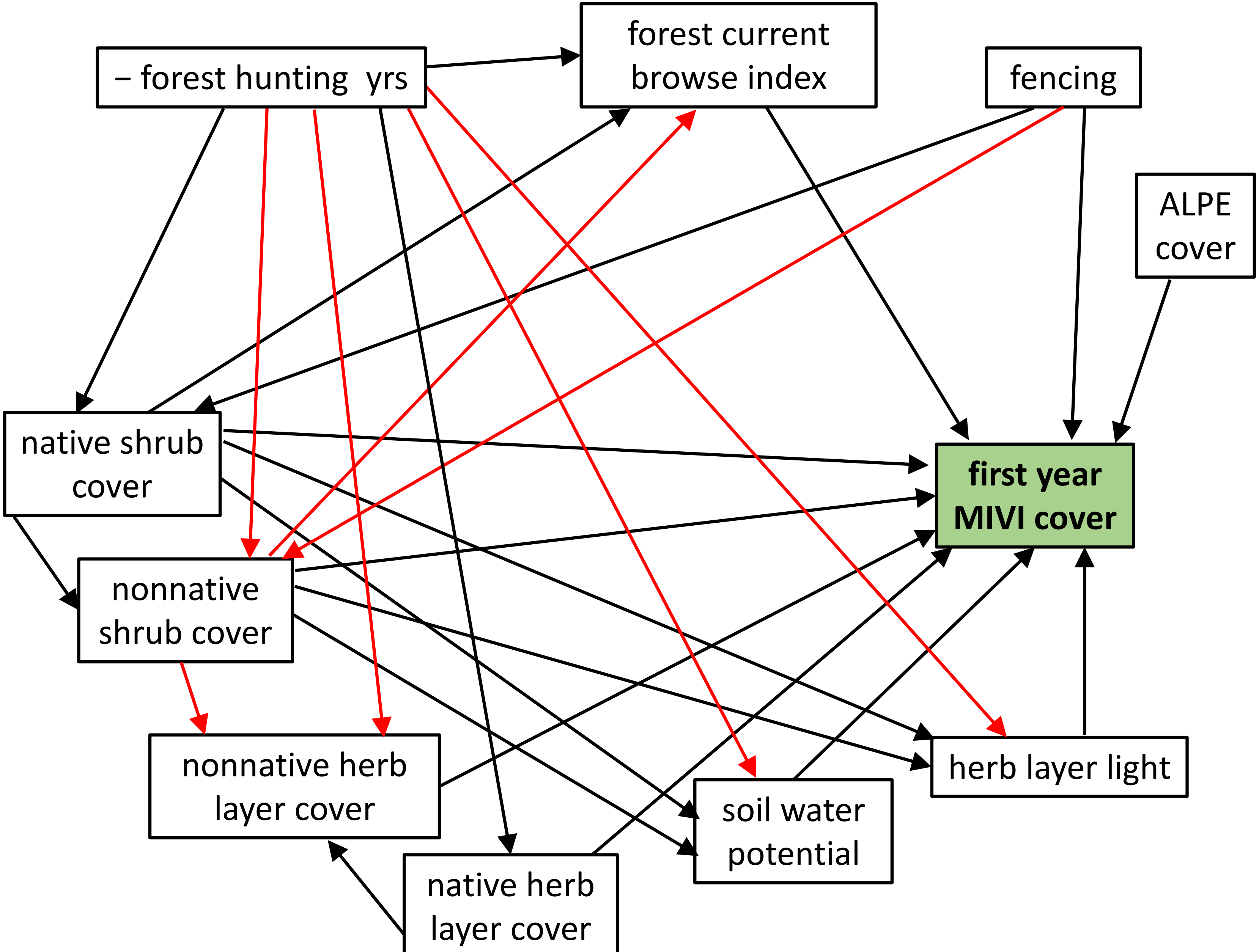

deer pressure
plant community
initial invasion
co-invasives
resources


chronic deer pressure
current deer pressure
plant community
initial invasion
co-invasives
resources

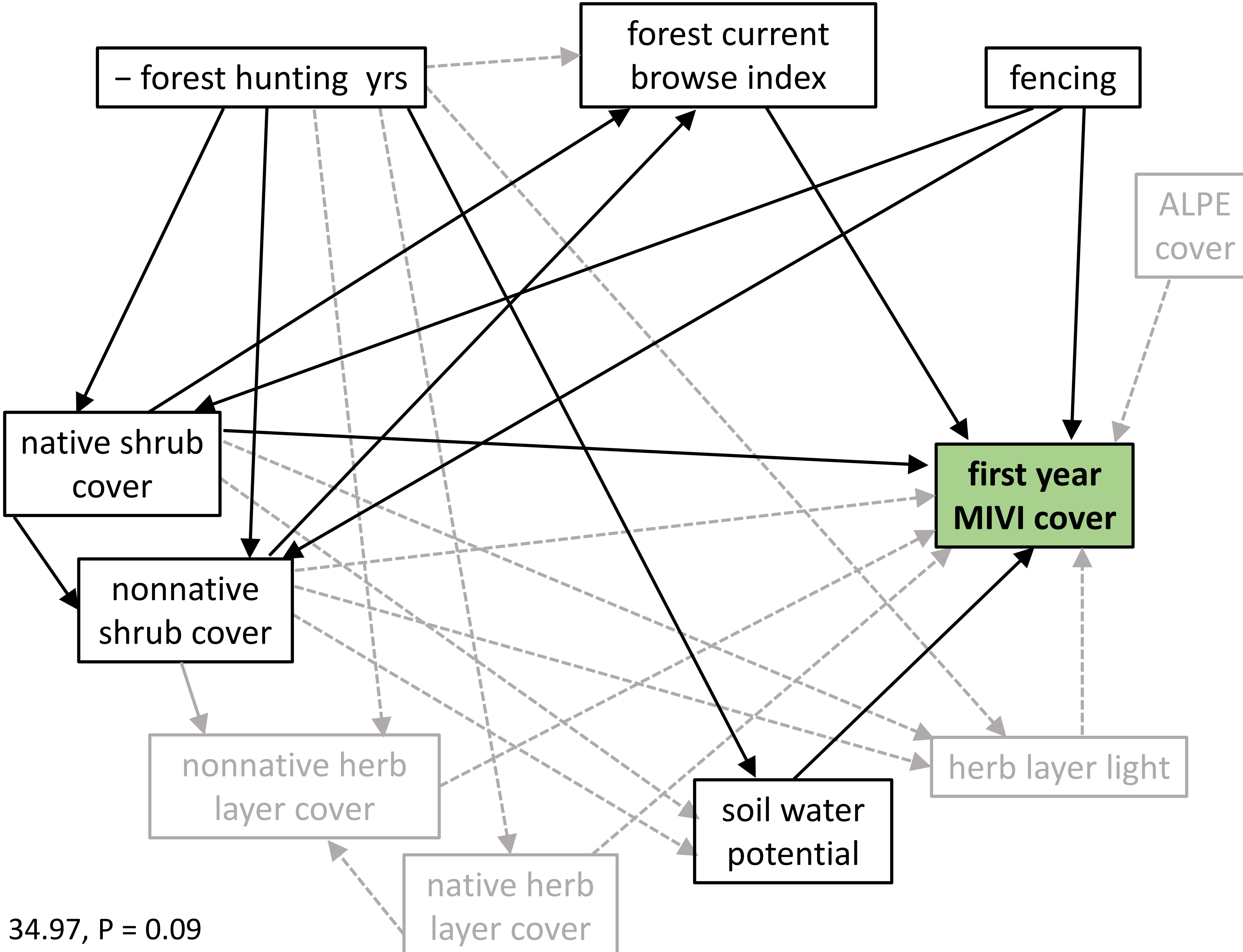

chronic deer pressure
current deer pressure
native plant community
initial invasion
co-invasives
non-native plant community
resources



− forest hunting yrs
forest current browse index
fencing
ALPE cover
native shrub cover
first year MIVI cover
nonnative shrub cover
nonnative herb layer cover
herb layer light
soil water potential
native herb layer cover
χ^2= 114.56, P<0.001
spring herb layer, early fall MIVI

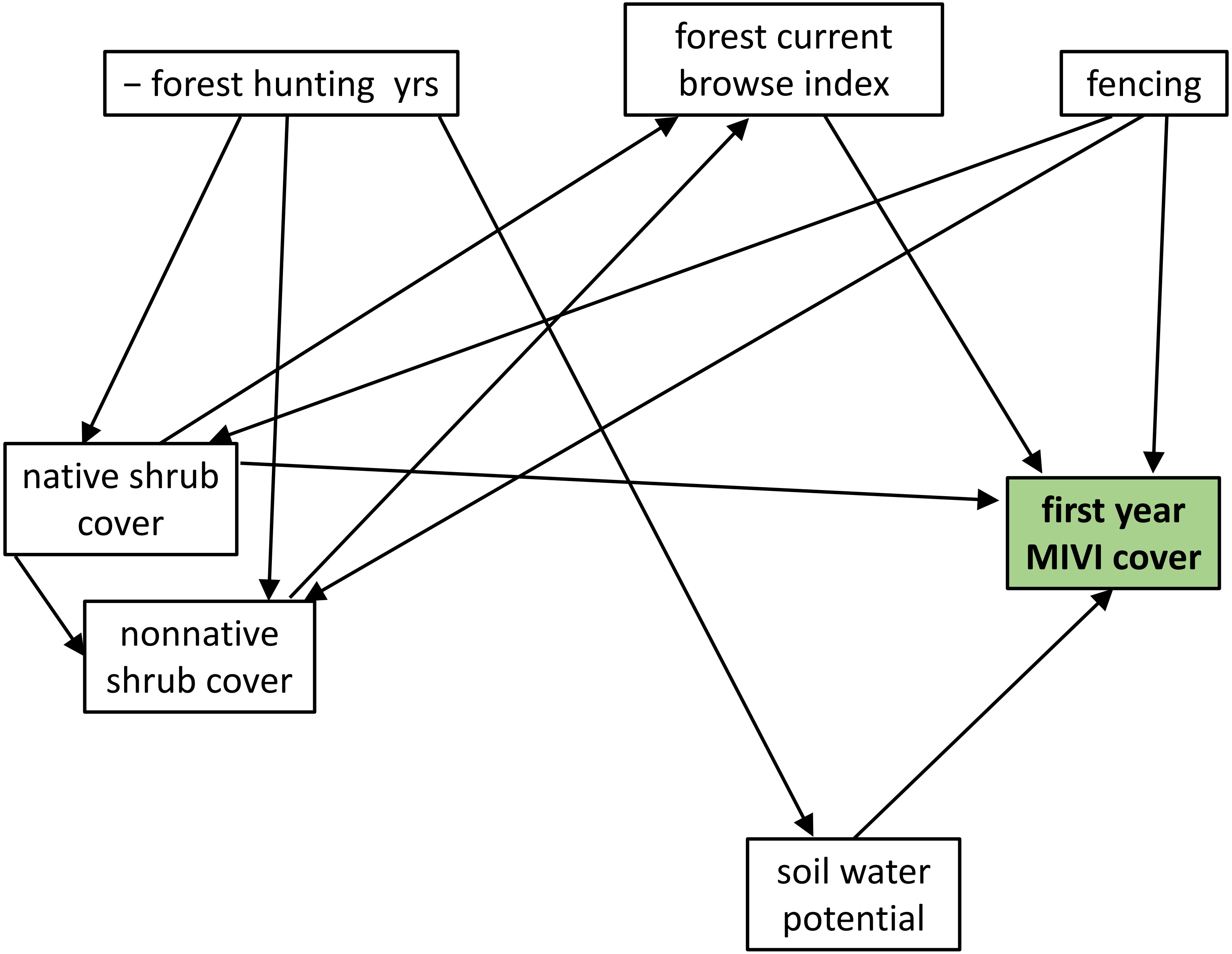


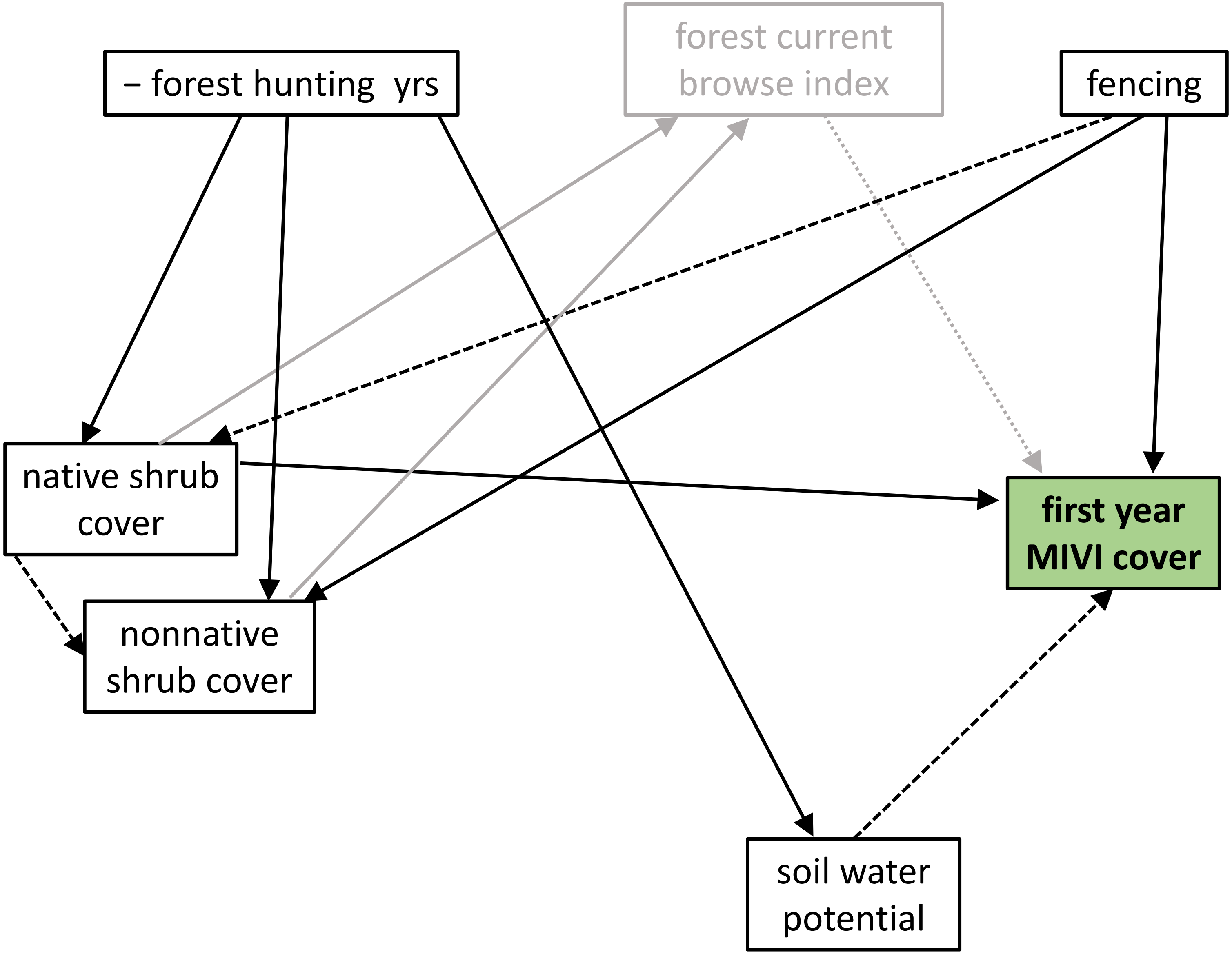
late spring herb layer, early fall MIVI



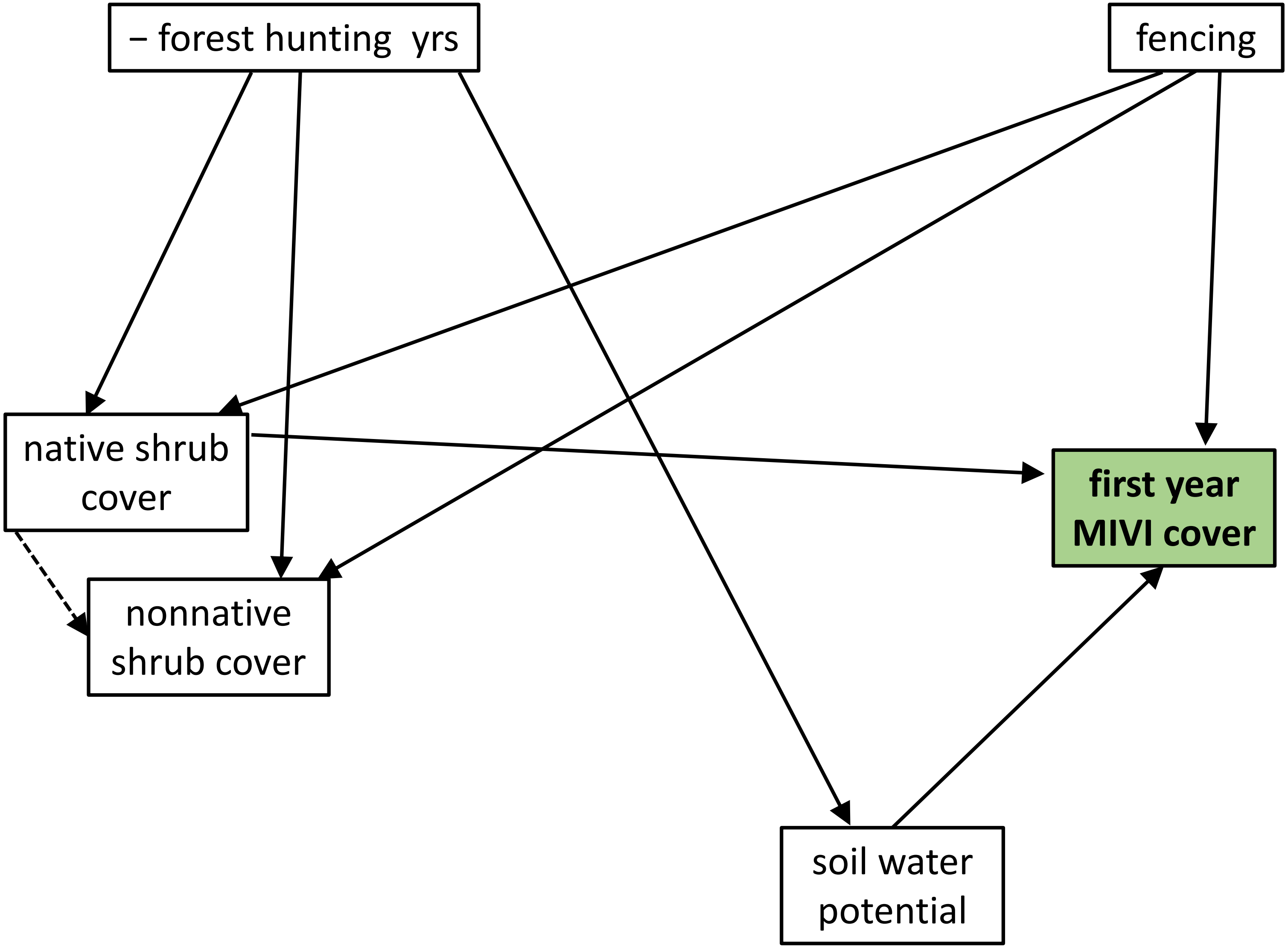
$\chi^2 = 34.97$, $P = 0.09$

late spring herb layer, early fall MIVI

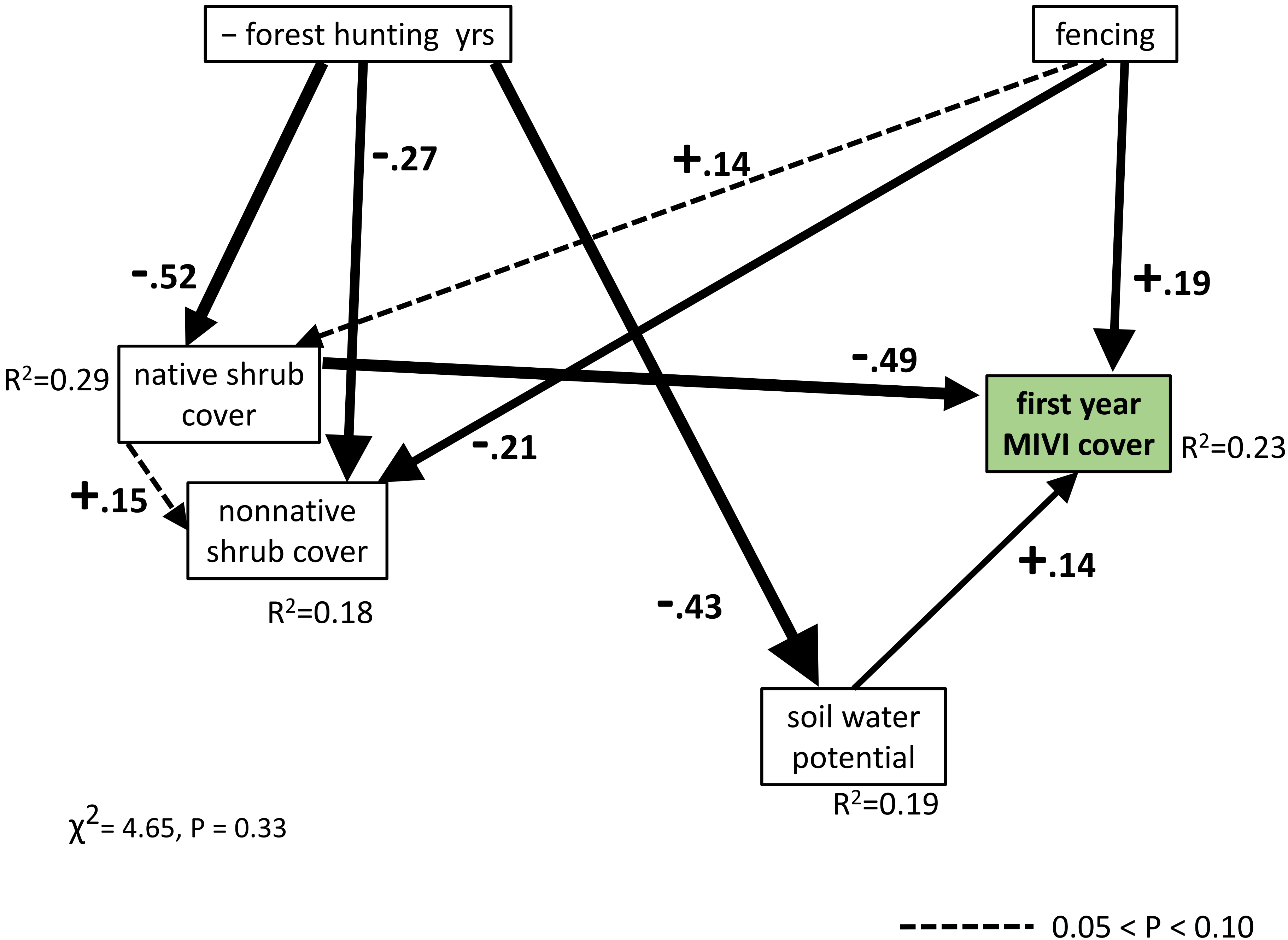

– forest hunting yrs
forest current browse index
fencing
native shrub cover
first year MIVI cover
nonnative shrub cover
soil water potential



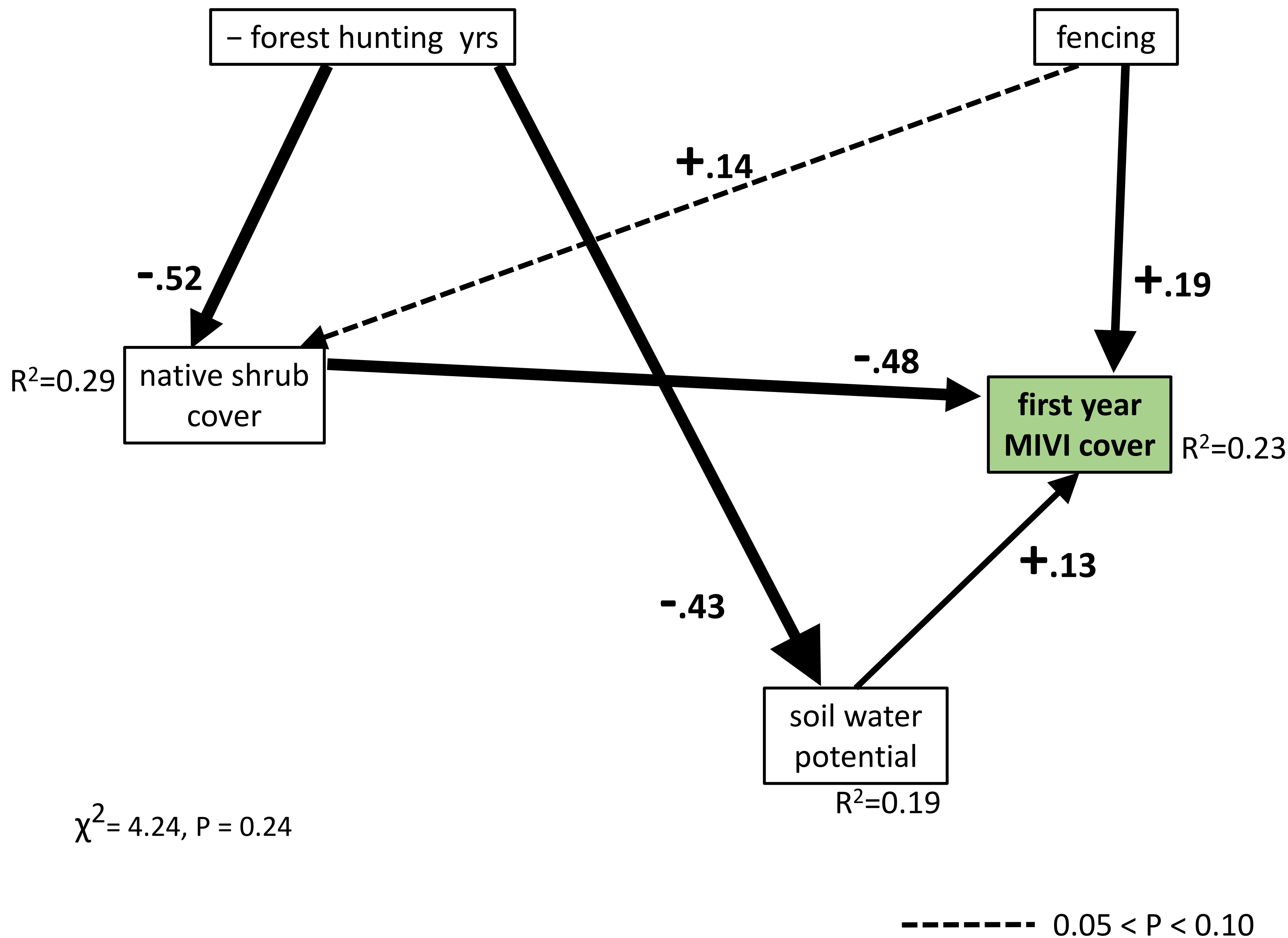
$\chi^2 = 8.07$, $P = 0.43$



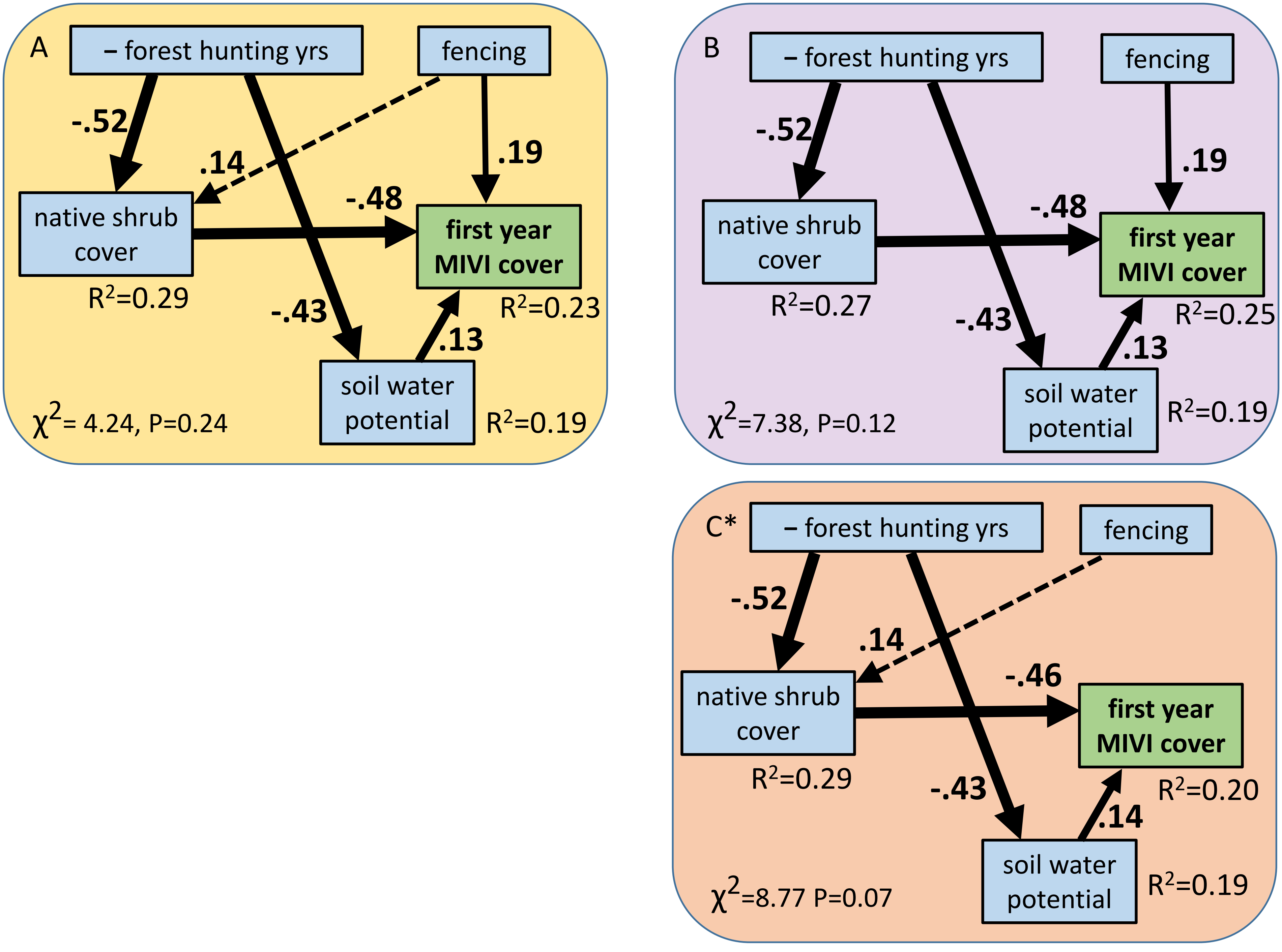
$\chi^2 = 8.07$, P = 0.43

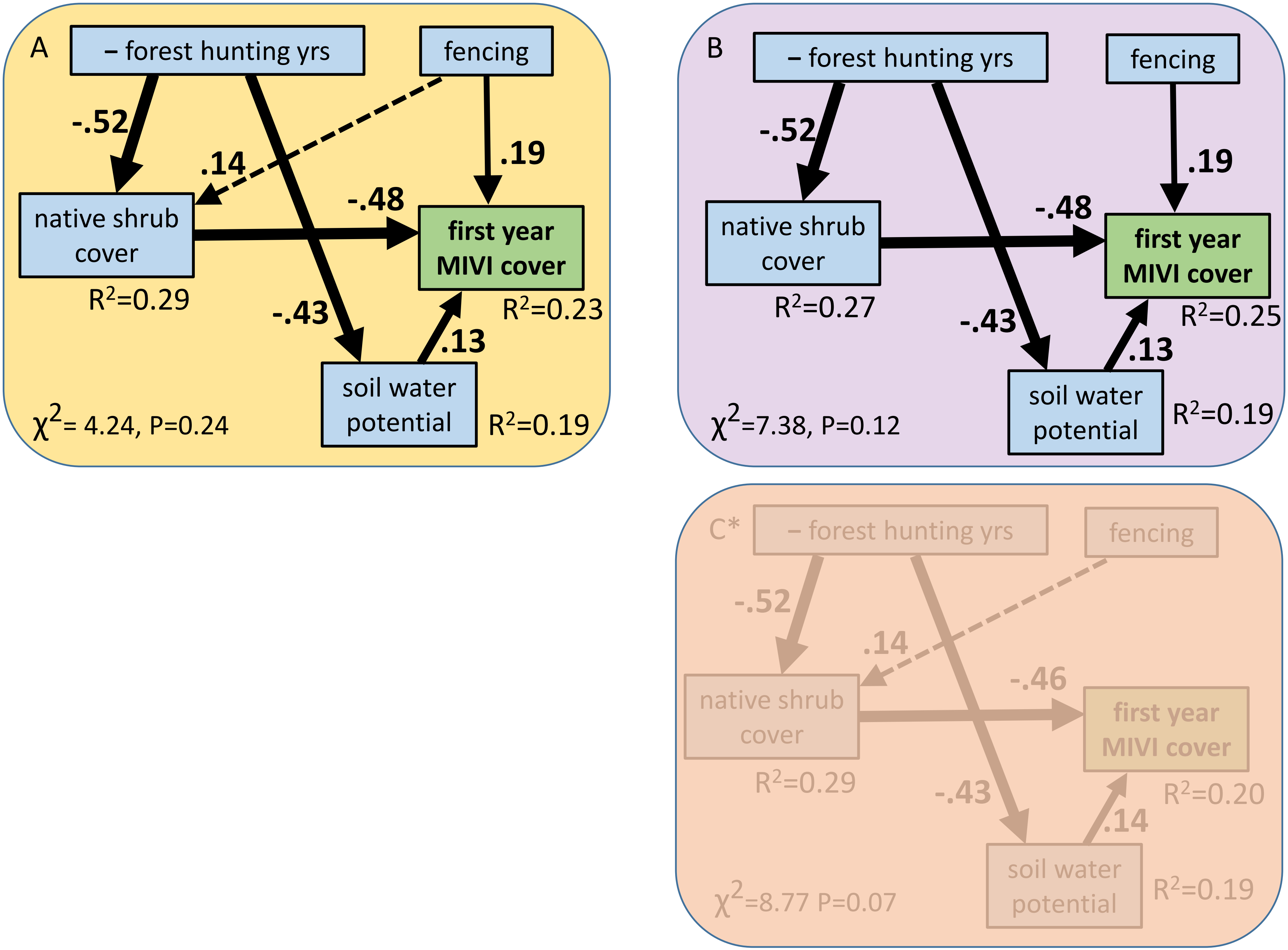


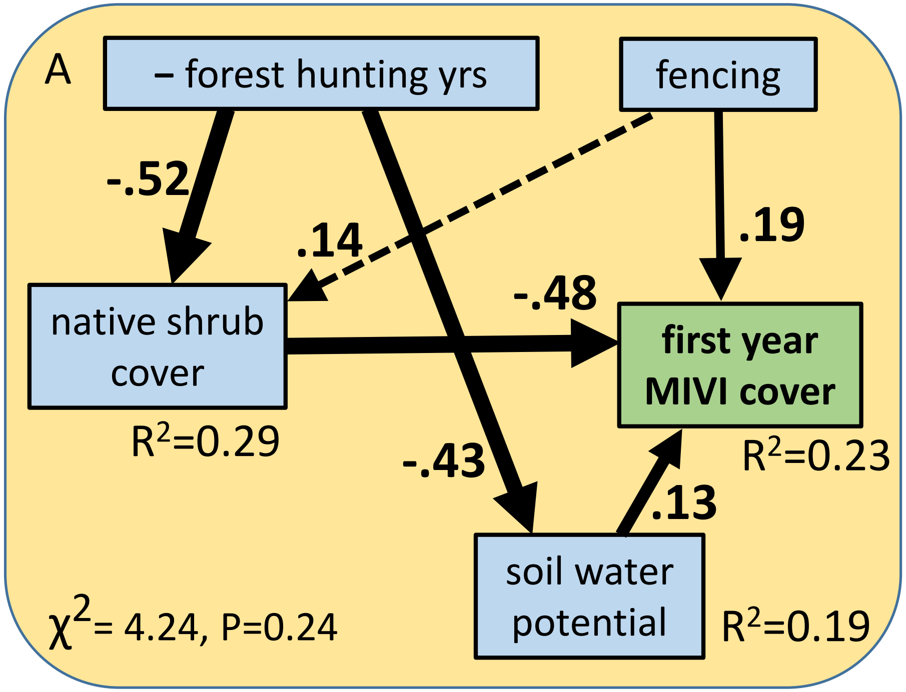
− forest hunting yrs
fencing
-.52
-.27
+.14
+.19
-.49
R²=0.29
native shrub cover
first year MIVI cover
R²=0.23
-.21
+.15
nonnative shrub cover
R²=0.18
+.14
-.43
soil water potential
R²=0.19
χ²= 4.65, P = 0.33
0.05 < P < 0.10



– forest hunting yrs
fencing
+.14
-.52
+.19
native shrub cover
R2=0.29
-.48
first year MIVI cover
R2=0.23
+.13
-.43
soil water potential
R2=0.19
χ2= 4.24, P = 0.24
0.05 < P < 0.10


A
− forest hunting yrs
fencing
-.52
.14
.19
-.48
native shrub cover
first year MIVI cover
R2=0.29
R2=0.23
-.43
.13
soil water potential
χ2= 4.24, P=0.24
R2=0.19
B
− forest hunting yrs
fencing
-.52
.19
-.48
native shrub cover
first year MIVI cover
R2=0.27
R2=0.25
-.43
.13
soil water potential
χ2=7.38, P=0.12
R2=0.19
C*
− forest hunting yrs
fencing
-.52
.14
-.46
native shrub cover
first year MIVI cover
R2=0.29
R2=0.20
-.43
.14
soil water potential
χ2=8.77 P=0.07
R2=0.19


A
− forest hunting yrs
fencing
-.52
.14
.19
-.48
native shrub cover
first year MIVI cover
R2=0.29
R2=0.23
-.43
.13
soil water potential
R2=0.19
χ2= 4.24, P=0.24
B
− forest hunting yrs
fencing
-.52
.19
-.48
native shrub cover
first year MIVI cover
R2=0.27
R2=0.25
-.43
.13
soil water potential
R2=0.19
χ2=7.38, P=0.12
C*
− forest hunting yrs
fencing
-.52
.14
-.46
native shrub cover
first year MIVI cover
R2=0.29
R2=0.20
-.43
.14
soil water potential
R2=0.19
χ2=8.77 P=0.07



1. Chronic deer pressure (& forest) had two indirect influences on initial MIVI invasion:

- positive, through its negative influence on native shrub cover

- negative, through its negative influence on soil moisture

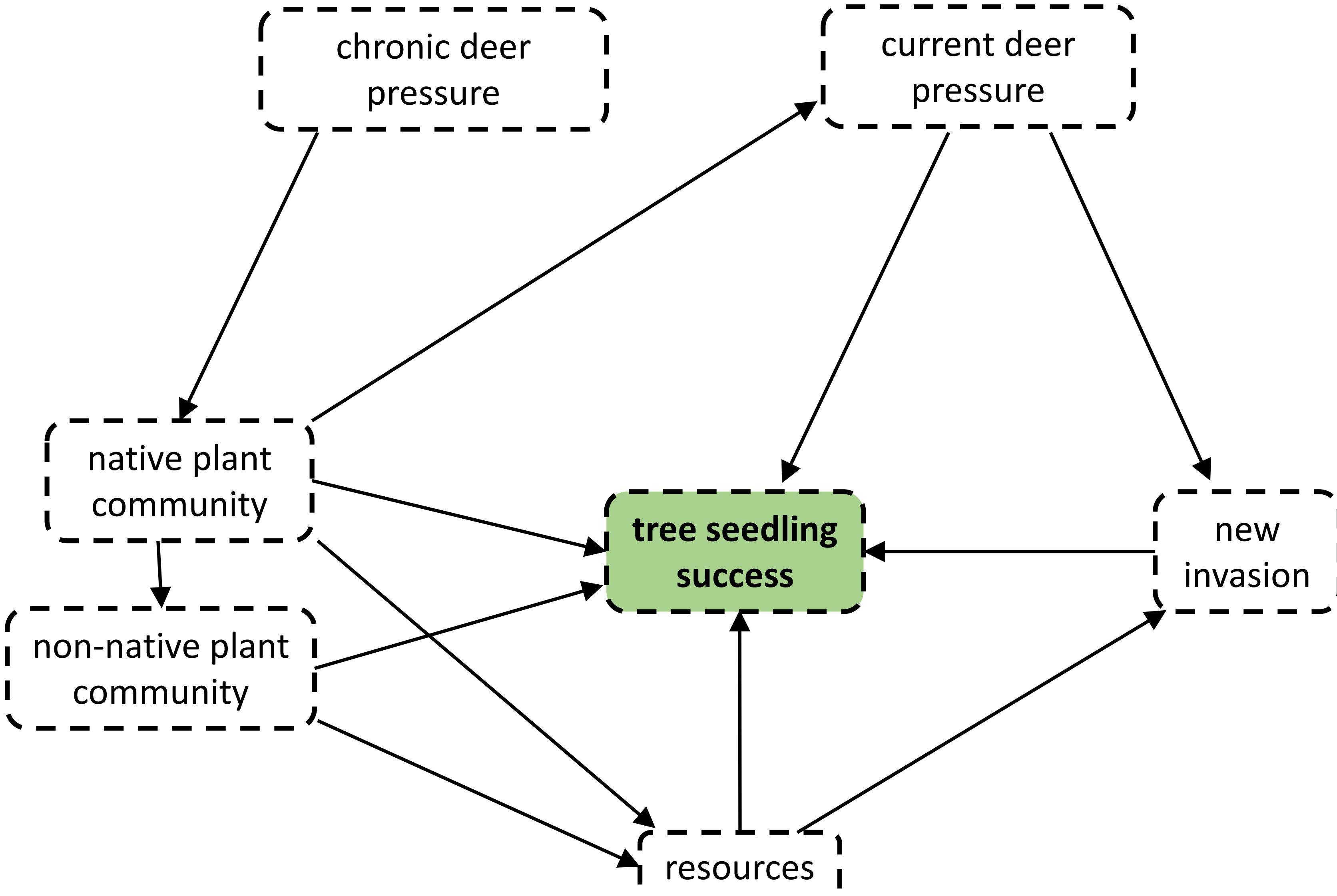
2. Excluding deer influenced initial MIVI invasion by a

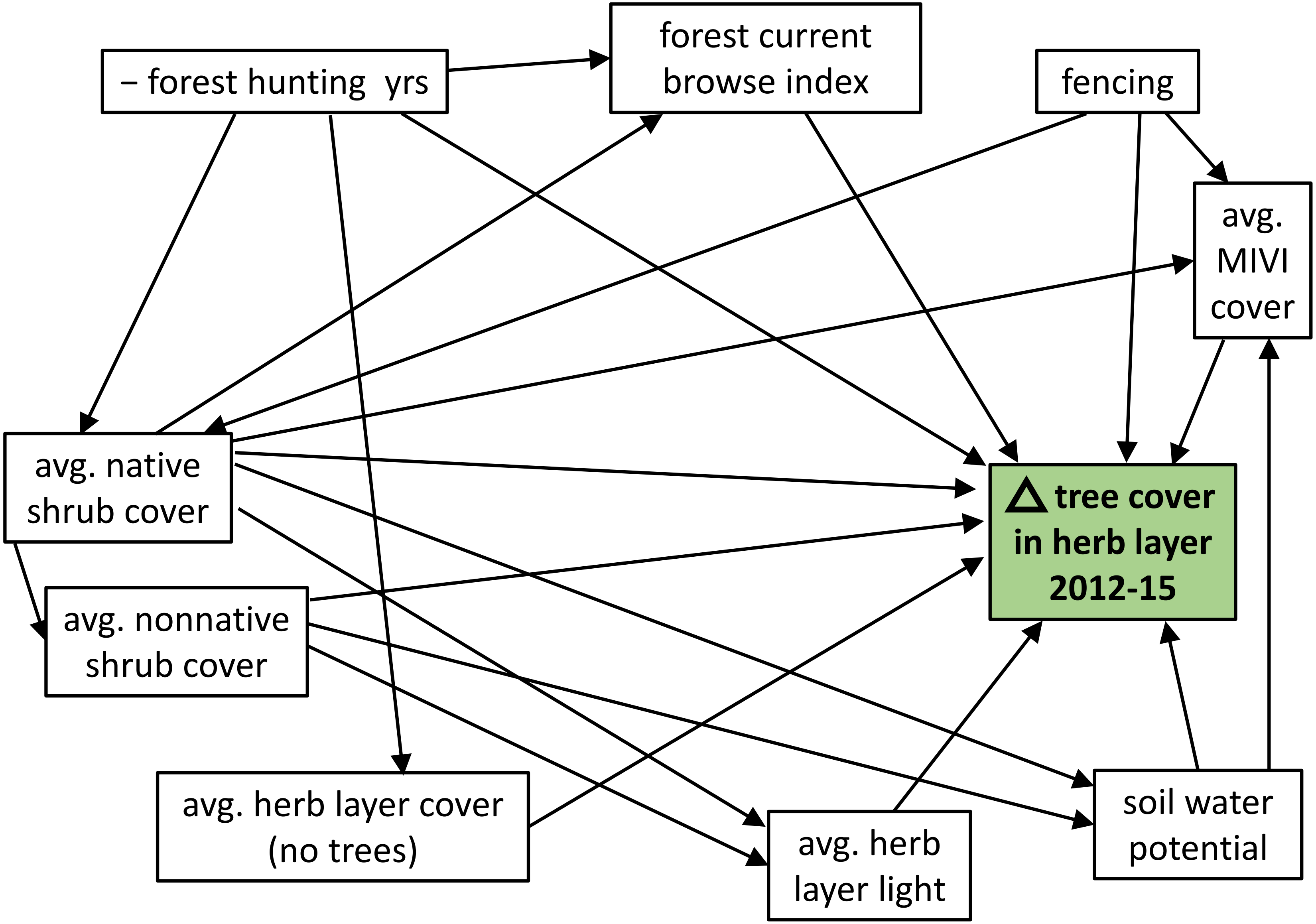
- positive, direct influence

- (slight) indirect negative influence, through its positive influence on native shrub cover

3. Suggests that MIVI is a passenger on changes caused by deer, but a greater proportion of initial MIVI invasion is unexplained than explained by this model.

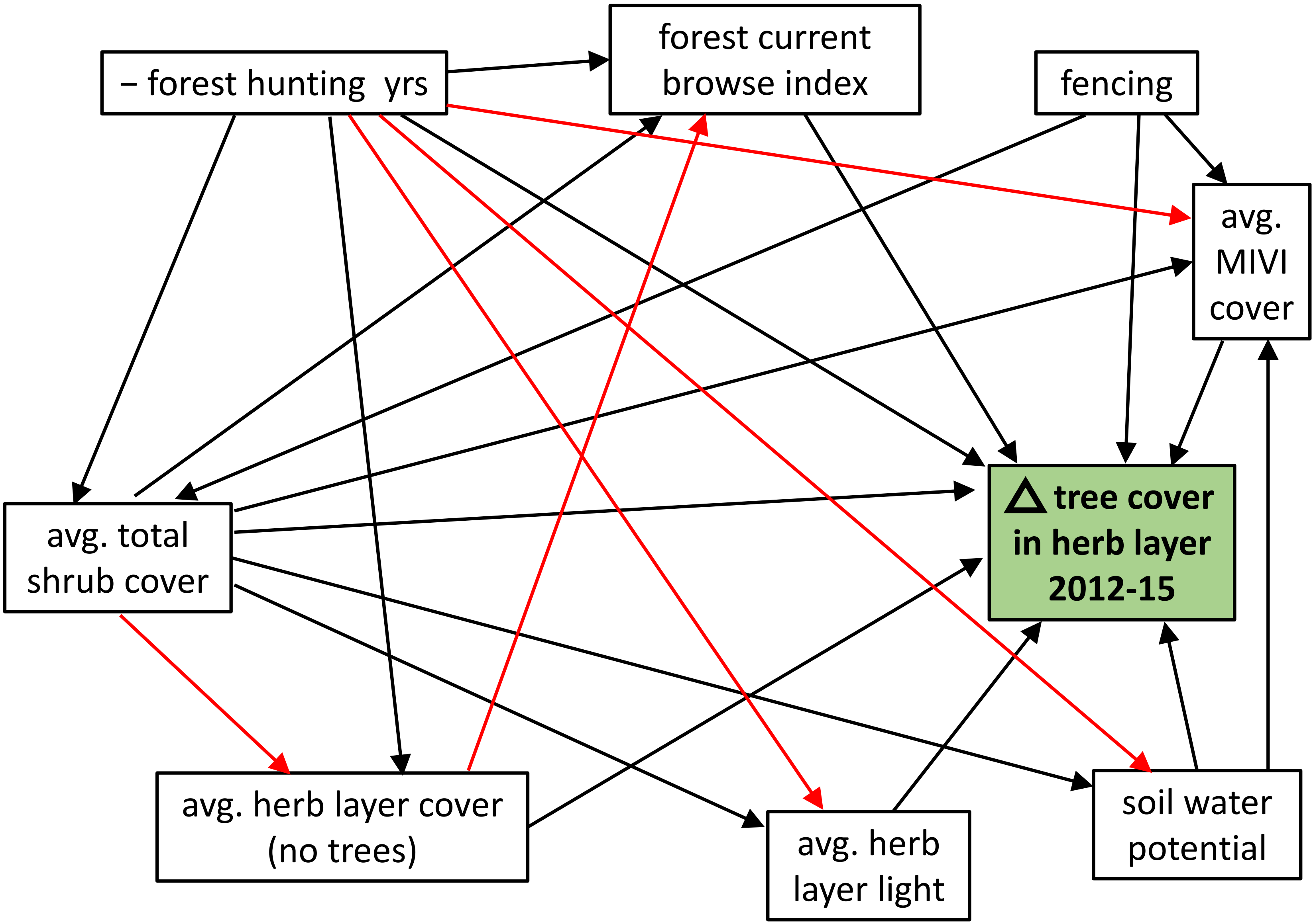
native trees in the herb layer


chronic deer pressure
current deer pressure
native plant community
tree seedling success
new invasion
non-native plant community
resources

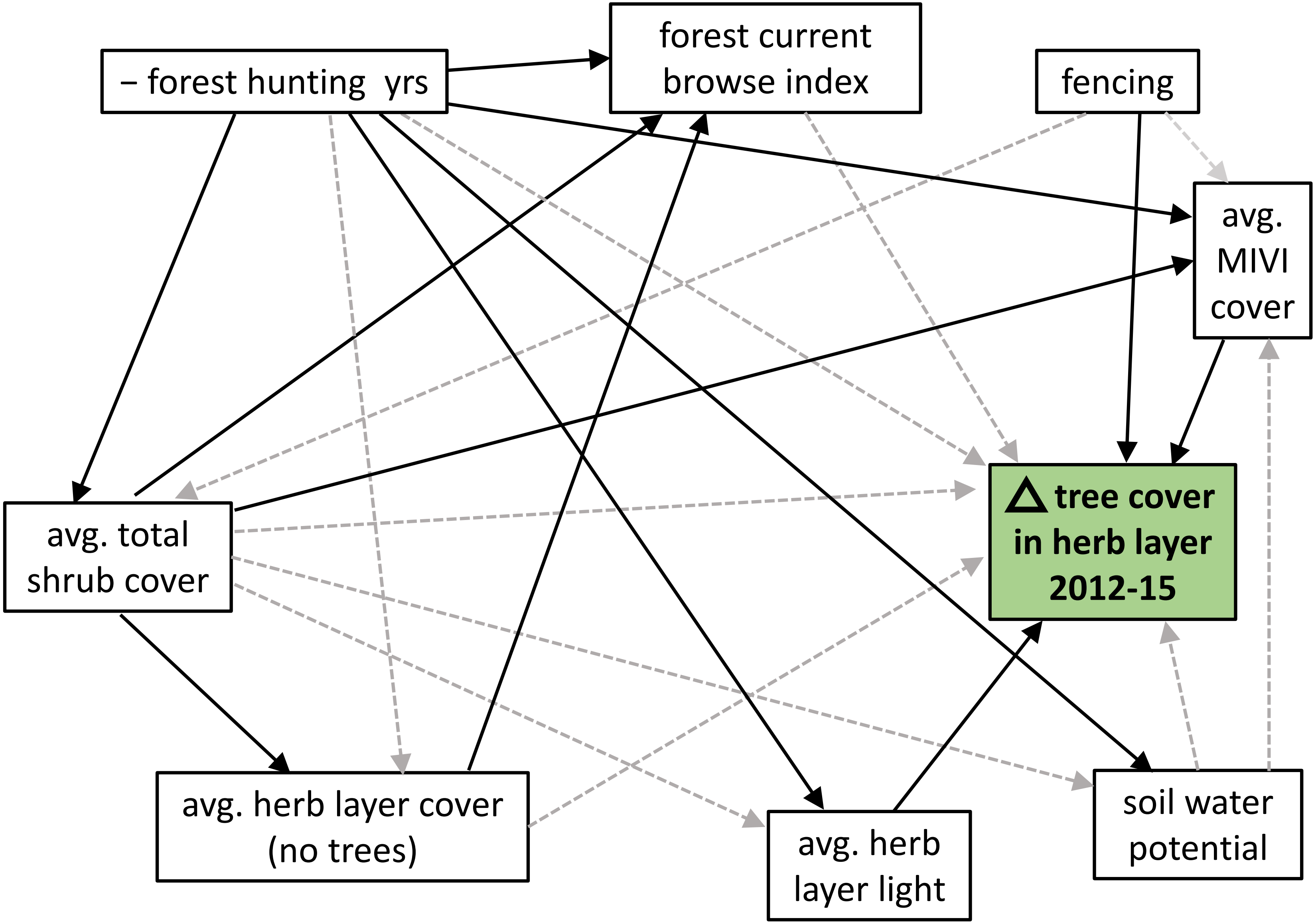


$\chi^2 = 106.62$, $P < 0.001$

late spring herb layer, 2012/13-2015 averages

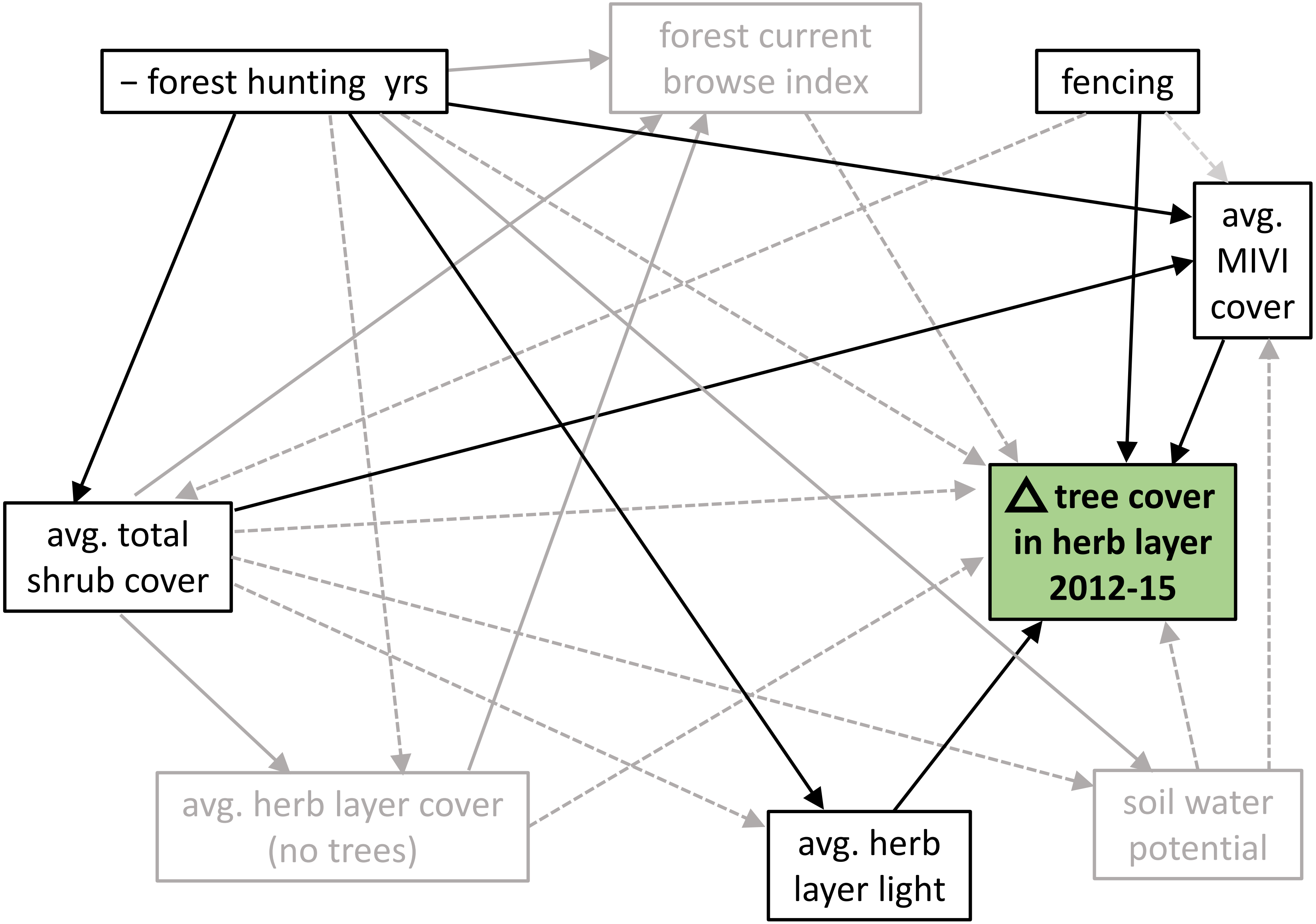


late spring herb layer, 2012/13-2015 averages

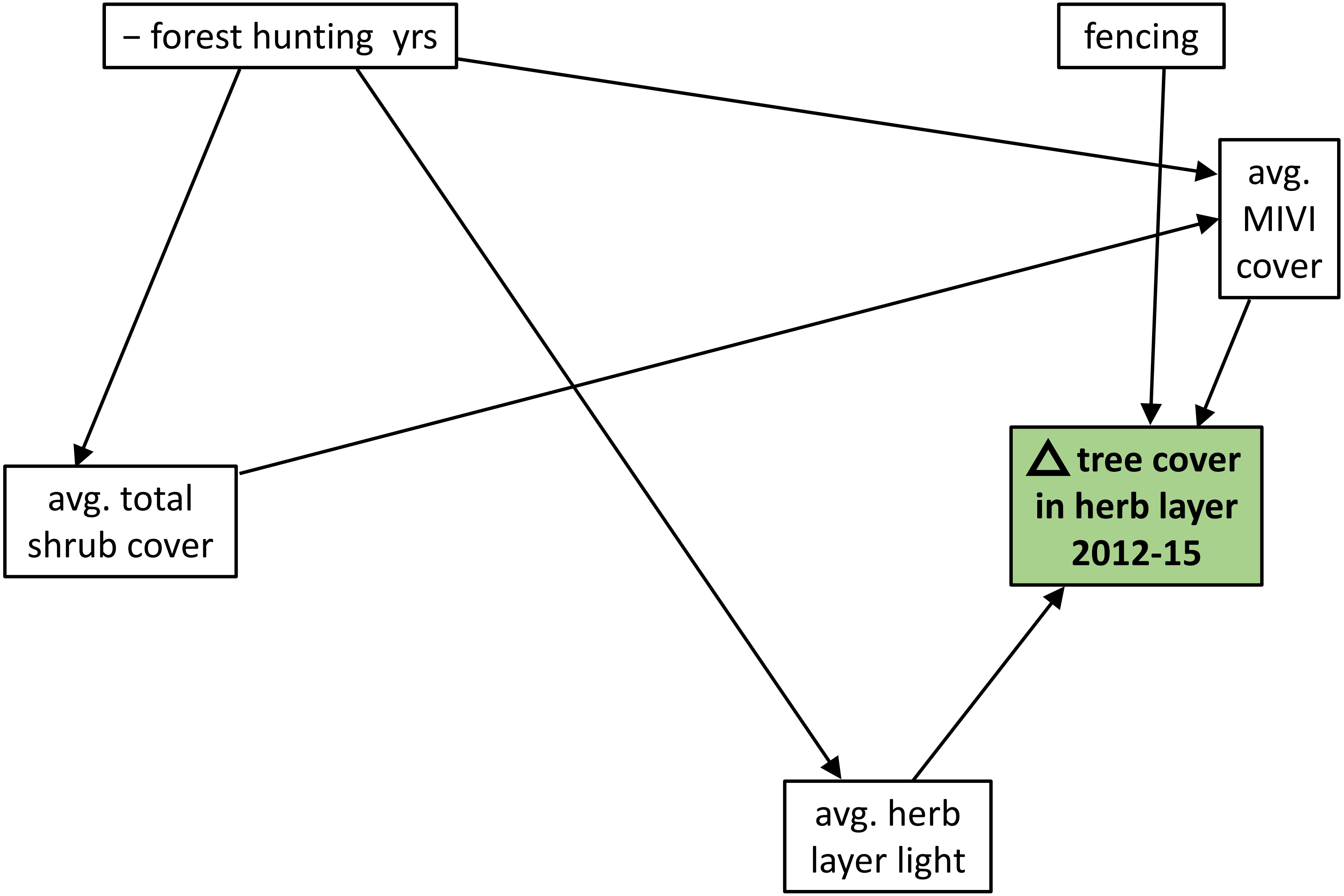


$\chi^2 = 30.23$ $P = 0.003$

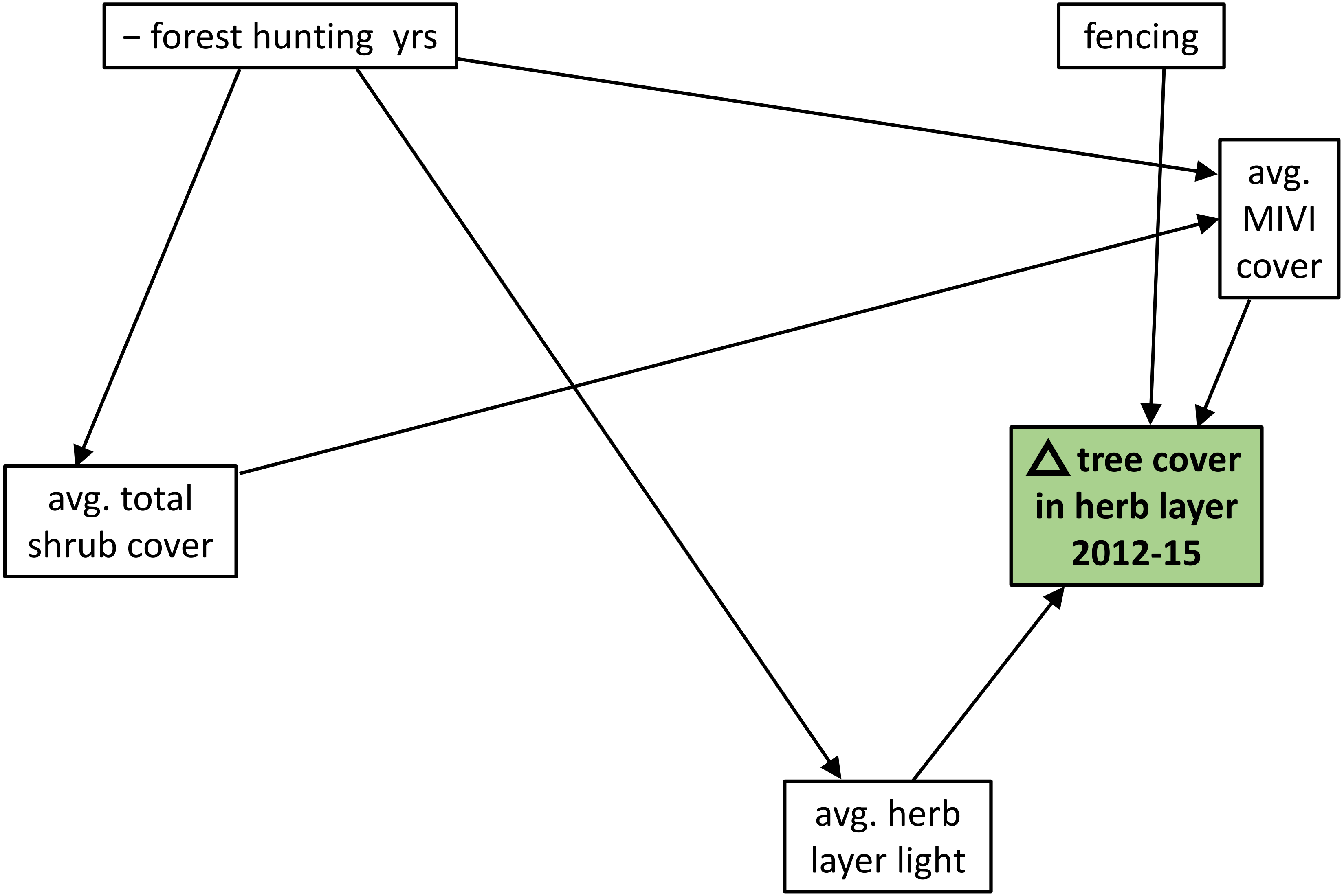
late spring herb layer,
2012/13-2015 averages



late spring herb layer,
2012/13-2015 averages

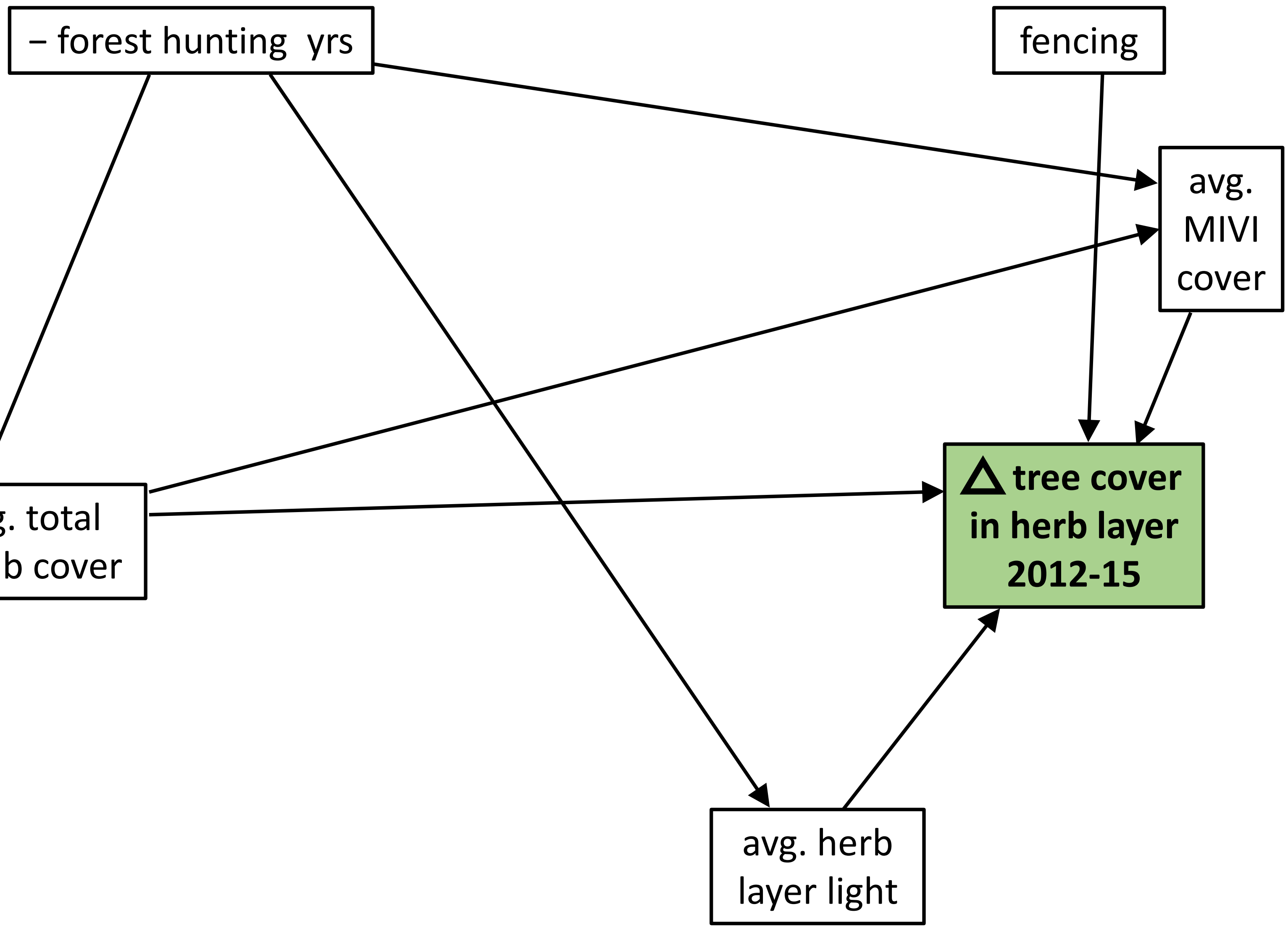


late spring herb layer, 2012/13-2015 averages

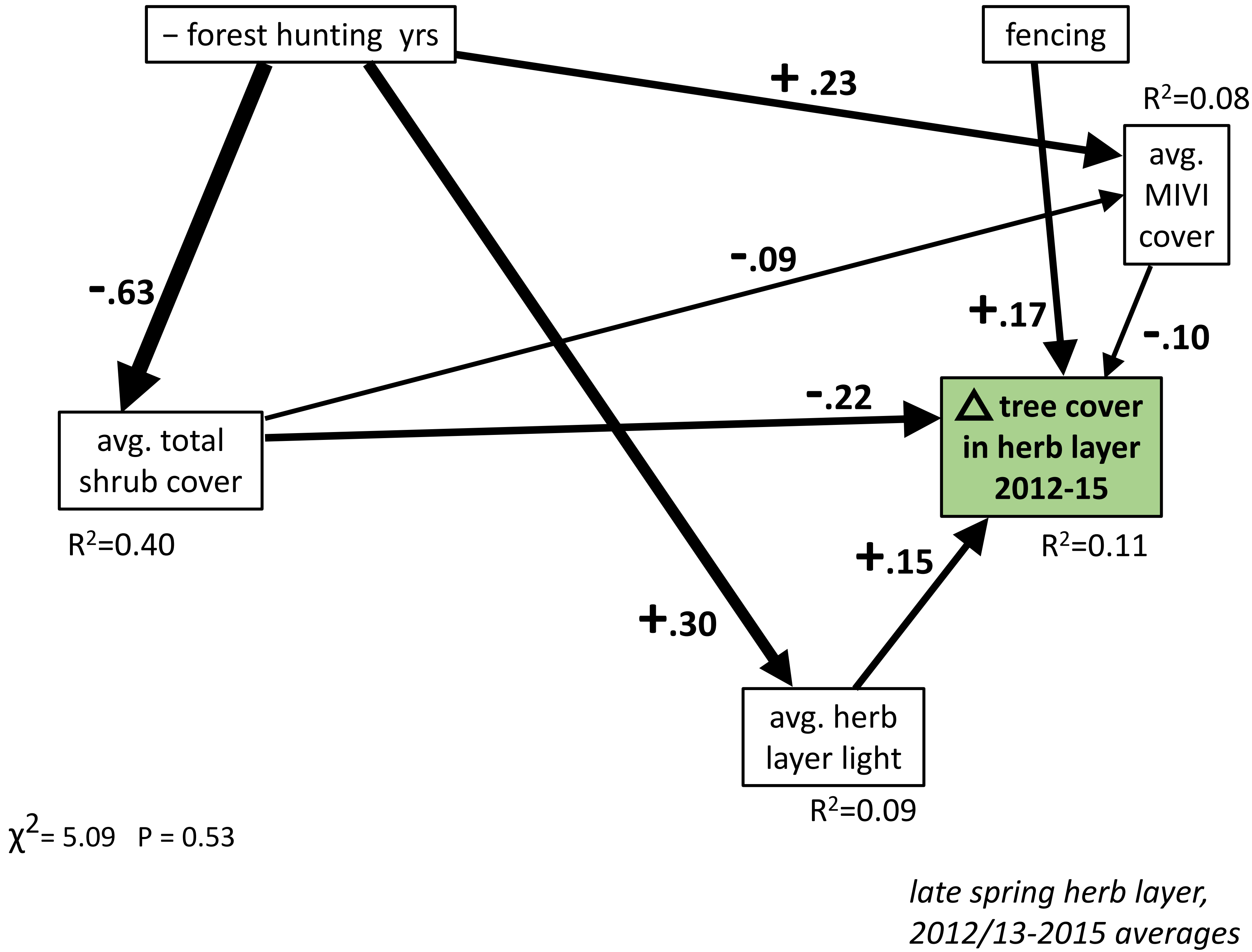


$\chi^2 = 16.16$ $P = 0.024$

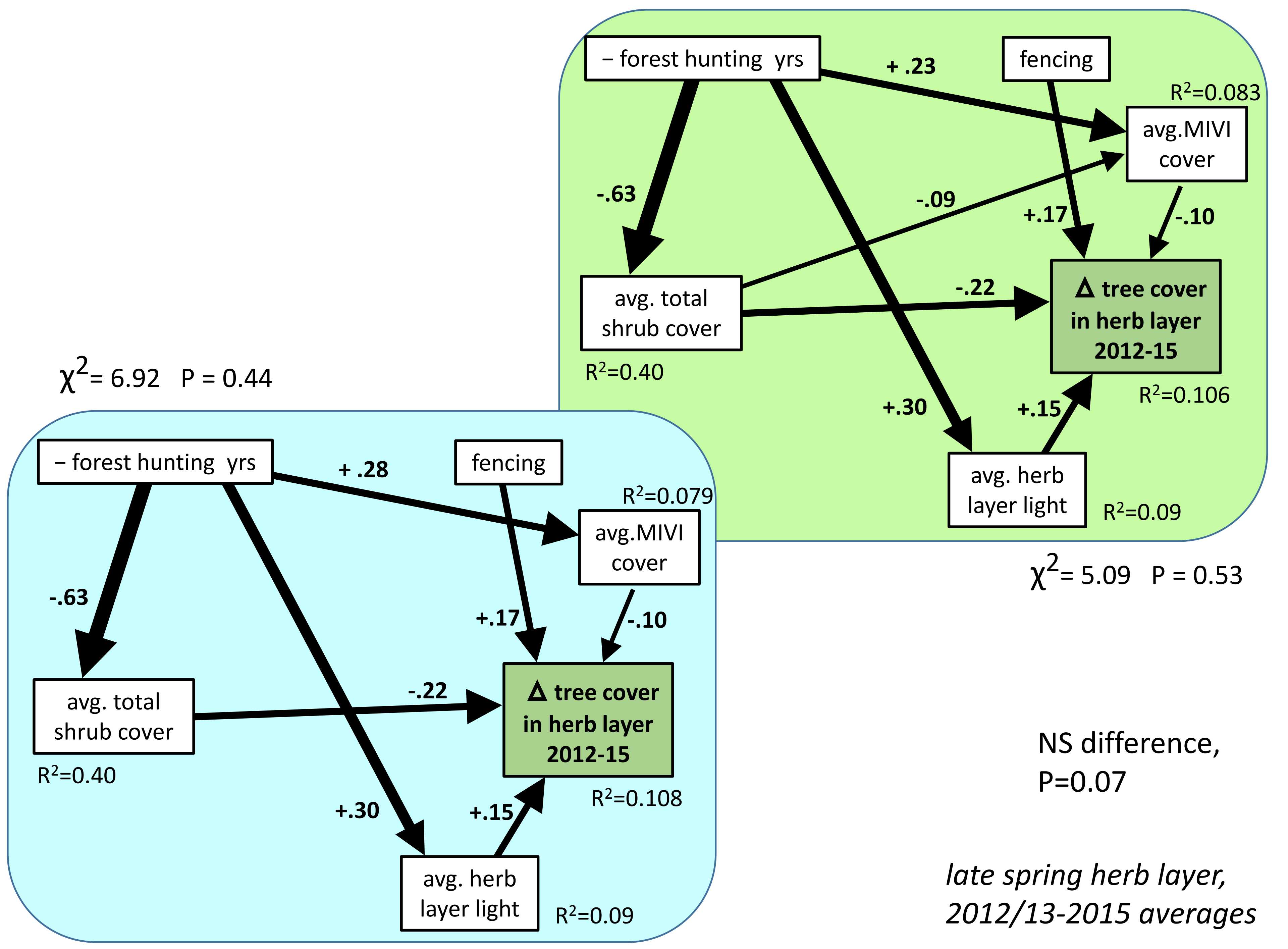
late spring herb layer, 2012/13-2015 averages



late spring herb layer,
2012/13-2015 averages



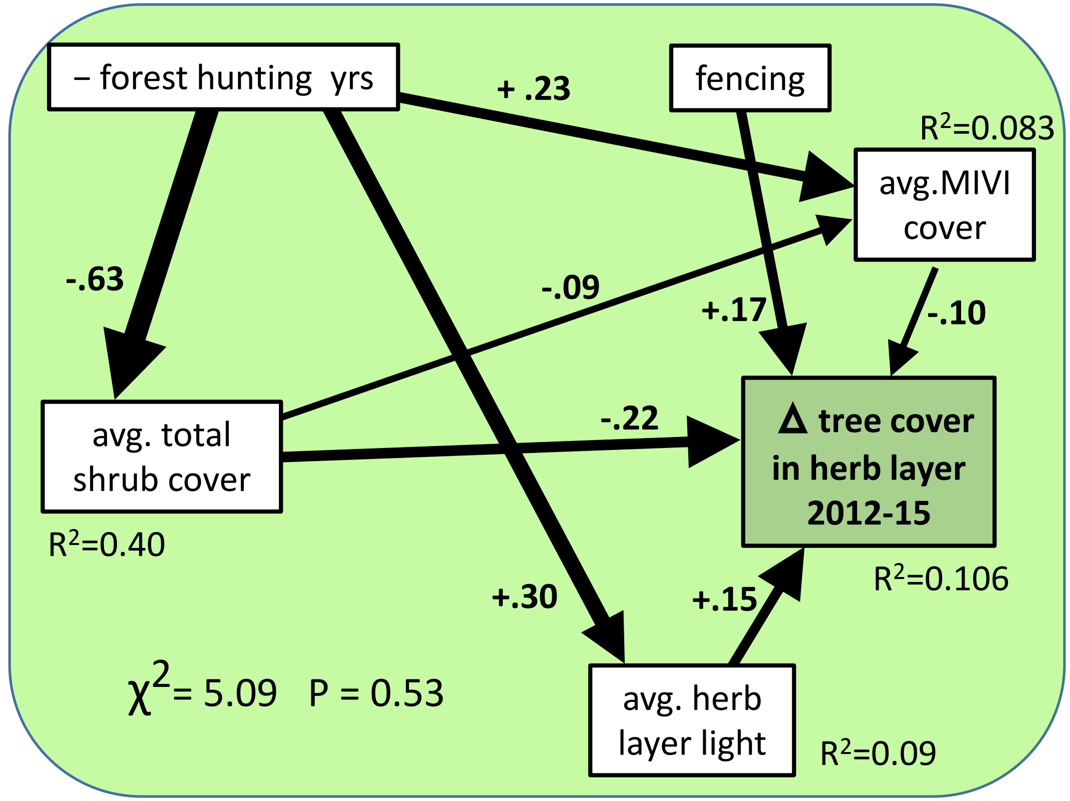
− forest hunting yrs
fencing
+ .23
R2=0.08
avg. MIVI cover
-.09
-.63
+.17
-.10
-.22
△ tree cover in herb layer 2012-15
avg. total shrub cover
R2=0.40
R2=0.11
+.15
+.30
avg. herb layer light
R2=0.09
χ2= 5.09 P = 0.53
late spring herb layer, 2012/13-2015 averages


− forest hunting yrs
fencing
+ .23
R2=0.083
avg.MIVI cover
-.63
-.09
+.17
-.10
avg. total shrub cover
-.22
Δ tree cover in herb layer 2012-15
R2=0.40
R2=0.106
+.30
+.15
avg. herb layer light
R2=0.09
χ2= 5.09 P = 0.53
χ2= 6.92 P = 0.44
− forest hunting yrs
fencing
+ .28
R2=0.079
avg.MIVI cover
-.63
+.17
-.10
avg. total shrub cover
-.22
Δ tree cover in herb layer 2012-15
R2=0.40
R2=0.108
+.30
+.15
avg. herb layer light
R2=0.09
NS difference, P=0.07
late spring herb layer, 2012/13-2015 averages

1. MIVI had a weak negative influence on tree seedlings.

2. Chronic deer pressure had three indirect influences on tree seedlings:
- positive, through a negative influence on native shrub cover
- positive, through a positive influence on light
- negative, through a positive influence on MIVI.

3. Deer exclusion had a direct, positive influence on tree seedlings.



4. Suggests that deer influences are stronger drivers of tree seedling success than competition from the invasive plant Microstegium vimineum

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