Appendix 1. Statistical models and software code.

**Statistical models**

Zero-inflated Poisson nonlinear mixed model (for seed bank density)

$$y\_{ijk}\~\left\{\begin{array}{c}0, \&with probability π\_{ijk}\\Poisson\left(μ\_{ijk}\right), \&with probability \left(1-π\_{ijk}\right)\end{array}\right.$$

$$logit \left(π\_{ijk}\right)=β\_{z\\_jk}+b\_{z\\_i}$$

$$log \left(μ\_{ijk}\right)=β\_{p\\_jk}+b\_{p\\_i}$$

$$E\left(y\_{ijk}\right)=μ\_{ijk}×\left(1-π\_{ijk}\right)$$

Generalized linear mixed model (for native seed density, species diversity, and soil comparisons among invasion histories)

$$y\_{ijk}=g^{-1}\left(μ+β\_{jk}+b\_{i}\right)$$

Linear mixed model (for vegetation cover)

$$y\_{ijk}=μ+β\_{jk}+b\_{i}+e\_{ijk}$$

Zero-inflated gamma nonlinear mixed model (for seed bank and seed bank–vegetation Sørensen values)

$$y\_{ijk}\~\left\{\begin{array}{c}0, \&with probability π\_{ijk}\\Gamma\left(k,θ\right), \&with probability \left(1-π\_{ijk}\right)\end{array}\right.$$

$$logit \left(π\_{ijk}\right)=β\_{z\\_jk}+b\_{z\\_i}$$

$$μ\_{ijk}=k×θ$$

$$log \left(μ\_{ijk}\right)=β\_{p\\_jk}+b\_{p\\_i}$$

$$E\left(y\_{ijk}\right)=μ\_{ijk}×\left(1-π\_{ijk}\right)$$

Generalized linear mixed model (for correlations of soils with seed banks and vegetation)

$$y\_{ijk}=g^{-1}\left(μ+α\_{k}+(αβ)\_{jk}+b\_{i}\right)$$

Model variables

*i* = 1, 2, 3 = sites

*j* = 1, 2, 3 = invasion histories

*k* = 1, 2, 3, … 94 = plots

$y\_{ijk}$ is the response variable for invasion history *j*, within site *i* plot *k*

$π\_{ijk}$ is the probability of the response variable being zero for invasion history *j* , within site *i* plot *k*

$μ\_{ijk}$ is the mean response variable for invasion history *j* within site *i* plot *k*

$β\_{jk}$ is the fixed effect of invasion history *j* on the response variable in plot *k*

$b\_{i}$ is the random effect of site *i* on the response variable

$E\left(y\_{ijk}\right)$ is the expected value of the response variable for invasion history *j* within site *i* plot *k*

$g$ is the link function

$μ$ is the mean response variable value

$e\_{ijk}$ is the random error for invasion history *j* in site *i* plot *k*.

$k$ is the shape parameter for the gamma distribution of the response variable

$θ$ is the scale parameter for the gamma distribution of the response variable

$α\_{k}$ is the linear combination of soil characteristic fixed effects on the response variable in plot *k*

$(αβ)\_{jk}$ is the linear combination of each soil characteristic’s interaction with invasion history

In the subscripts for these models, *z* indicates zero values and *p* indicates positive non-zero values.

**SAS/STAT code to estimate the zero-inflated Poisson nonlinear mixed model.** The following code was used to test the hypothesis that seed density varied among invasion histories. The code first sorts the data according to the random effect Site, which is required by the NLMIXED procedure. Note: The random effects are u1 (for the zero part) and u2 (for the non-zero part), and s2u1 and s2u2 are their respective variances. This model assumes a normal distribution and zero covariance for the random effects.

**proc** **sort** data=seeddens07;

 by Site;

**run**;

**proc** **nlmixed** data=seeddens07;

parms b0=**0** b1=**0** b2=**0**

a0=**0** a1=**0** a2=**0**;

x1 = **0**; if Treatment='inf-nat' then x1=**1**;

x2 = **0**; if Treatment='inf-ex' then x2=**1**;

/ Linear model components for zero and non-zero values /

linpinfl = a0 + a1x1 + a2x2 + u1;

infprob = **1**/(**1** + exp(-linpinfl));

lambda = exp(b0 + b1x1 + b2x2 + u2);

/ Log likelihood (ll) functions for zero and non-zero probabilities /

if Seed\_count=**0** then

 ll = log(infprob + (**1**-infprob)exp(-lambda));

else ll = log((**1**-infprob)) - lambda + Seed\_countlog(lambda) - lgamma(Seed\_count + **1**);

model Seed\_count ~ general(ll);

random u1 u2 ~ normal([**0**,**0**],[s2u1, **0**, s2u2]) subject=Site;

/ Predictions for seed counts based on the model /

predict (**1** - infprob)lambda out=expect\_zip;

/ Contrasts and estimates for testing hypotheses regarding treatment effects on probability of zeroes and seed counts /

contrast "Diff in zero probability across invasion histories"

 **1**/(**1** + exp(-a0 - a1)) - **1**/(**1** + exp(-a0)),

 **1**/(**1** + exp(-a0 - a2)) - **1**/(**1** + exp(-a0)),

 **1**/(**1** + exp(-a0 - a2)) - **1**/(**1** + exp(-a0 - a1));

contrast "Diff in # seeds across invasion history treatments"

 exp(b0 + b1)(**1** - **1**/(**1** + exp(-a0 - a1))) - exp(b0)(**1** - **1**/(**1** + exp(-a0))),

 exp(b0 + b2)(**1** - **1**/(**1** + exp(-a0 - a2))) - exp(b0)(**1** - **1**/(**1** + exp(-a0))),

 exp(b0 + b2)(**1** - **1**/(**1** + exp(-a0 - a2))) - exp(b0 + b1)(**1** - **1**/(**1** + exp(-a0 - a1)));

estimate "Probability of zeroes in Native" **1**/(**1** + exp(-a0));

estimate "Probability of zeroes in Invaded-Native" **1**/(**1** + exp(-a0 - a1));

estimate "Probability of zeroes in Invaded-Exotic" **1**/(**1** + exp(-a0 - a2));

estimate "Seed density in Native" exp(b0)(**1**-**1**/(**1** + exp(-a0)));

estimate "Seed density in Invaded-Native"

 exp(b0 + b1)(**1** - **1**/(**1** + exp(-a0 - a1)));

estimate "Seed density in Invaded-Exotic"

 exp(b0 + b2)(**1** - **1**/(**1** + exp(-a0 - a2)));

estimate "Diff. in zero probability between Native and Invaded-Native"

 **1**/(**1** + exp(-a0 - a1)) - **1**/(**1** + exp(-a0));

estimate "Diff. in zero probability between Native and Invaded-Exotic"

 **1**/(**1** + exp(-a0 - a2)) - **1**/(**1** + exp(-a0));

estimate "Diff. in zero probability between Invaded-Native and Invaded-Exotic" **1**/(**1** + exp(-a0 - a2)) - **1**/(**1** + exp(-a0 - a1));

estimate "Diff. in seed density between Native and Invaded-Native"

 exp(b0 + b1)(**1** - **1**/(**1** + exp(-a0 - a1))) - exp(b0)(**1** - **1**/(**1** + exp(-a0)));

estimate "Diff. in seed density between Native and Invaded-Exotic"

 exp(b0 + b2)(**1** - **1**/(**1** + exp(-a0 - a2))) - exp(b0)(**1** - **1**/(**1** + exp(-a0)));

estimate "Diff. in seed density between Invaded-Native and Invaded-Exotic"

 exp(b0 + b1)(**1** - **1**/(**1** + exp(-a0 - a1))) - exp(b0 + b2)(**1** - **1**/(**1** + exp(-a0 - a2)));

**run**;

/ Calculation for residual values /

**data** expect\_zip;

 set expect\_zip;

 resid=Seed\_count-Pred;

**run**;

/ Residual plot of predicted vs. residual values /

**proc** **sgplot** data=expect\_zip;

 scatter x=Pred y=resid;

**run**;

**SAS/STAT code to estimate the generalized linear mixed model.** The following code was used to test the hypothesis that vegetation and seed bank richness varied among invasion histories.

**proc** **sort** data=Diversity3 out=diverse1;

by Sampling Year;

**run**;

ods graphics on;

**proc** **glimmix** data=diverse1 plots=boxplot plots=residualpanel(conditional marginal);

by Sampling Year;

class Year Site Treatment;

model Richness=Treatment/solution ddfm=kr link=log dist=poisson;

random Site;

lsmeans Treatment / adjust=tukey;

**run**;

ods graphics off;

**SAS/STAT code to estimate the linear mixed model.** The following code was used to test the hypotheses that vegetation cover, similarity of species within the vegetation, and similarity of species between seed bank and vegetation varied among invasion histories. Identical code, with different data sets and parameters, was used on vegetation evenness and Shannon’s diversity.

**proc** **sort** data=vegcover out=vegcover1;

 by Year;

**run**;

**proc** **mixed** data=vegcover1

 plots=residualpanel(conditional marginal box)

 plots=studentpanel(box)

 plots=boxplot(random marginal conditional observed fixed);

 by Year;

 class Year Site Treatment;

 model Cover=Treatment/solution ddfm=kr residual;

 random Site;

 lsmeans Treatment / diff cl adjdfe=row adjust=tukey;

**run**;

**SAS/STAT code to estimate the zero-inflated gamma nonlinear mixed model.** The following code was used to test the hypothesis that similarity of species within the seed bank varied among invasion histories. The code first sorts the data according to the random effect Site, which is required by the NLMIXED procedure. Note: The random effects are u1 (for the zero part) and u2 (for the non-zero part), and s2u1 and s2u2 are their respective variances. This model assumes a normal distribution and zero covariance for the random effects.

**proc** **sort** data=seedsim3 out=seedsim4;

by Site\_comb;

**run**;

**proc** **nlmixed** data=seedsim4;

parms b0\_f=**0** b1\_f=**0** b2\_f=**0**

b0\_h=**0** b1\_h=**0** b2\_h=**0**

log\_theta=**0**;

x1 = **0**; if Treat\_comb='IN-IN' then x1=**1**;

x2 = **0**; if Treat\_comb='IE-IE' then x2=**1**;

/ Linear model components for zero and non-zero values /

eta\_f = b0\_f + b1\_fx1 + b2\_fx2 + u1;

p\_yEQ0 = **1** / (**1** + exp(-eta\_f));

eta\_h = b0\_h + b1\_hx1 + b2\_hx2 + u2;

mu = exp(eta\_h);

theta = exp(log\_theta);

r = mu/theta;

/ Log likelihood (ll) functions for zero and non-zero probabilities /

if Sorensen=**0** then

 ll = log(p\_yEQ0);

else ll = log(**1** - p\_yEQ0)- lgamma(theta) + (theta-**1**)log(Sorensen) - thetalog(r) - Sorensen/r;

model Sorensen ~ general(ll);

random u1 u2 ~ normal([**0**,**0**],[s2u1, **0**, s2u2]) subject=Site\_comb;

predict (**1** - p\_yEQ0)mu out=expect\_zig;

/ Contrasts and estimates for testing hypotheses regarding treatment effects on probability of zeroes positive Sorensen values /

contrast "Diff. in zero probability across invasion histories"

**1**/(**1** + exp(-b0\_f - b1\_f)) - **1**/(**1** + exp(-b0\_f)),

**1**/(**1** + exp(-b0\_f - b1\_f)) - **1**/(**1** + exp(-b0\_f)),

**1**/(**1** + exp(-b0\_f - b2\_f)) - **1**/(**1** + exp(-b0\_f - b1\_f));

contrast "Diff across trts in E(Y)"

 exp(b0\_h + b1\_h)(**1** - **1**/(**1** + exp(-b0\_f - b1\_f))) - exp(b0\_h)(**1** - **1**/(**1** + exp(-b0\_f))),

 exp(b0\_h + b2\_h)(**1** - **1**/(**1** + exp(-b0\_f - b2\_f))) - exp(b0\_h)(**1** - **1**/(**1** + exp(-b0\_f)));

estimate "Probability of zeroes in N-N" **1**/(**1** + exp(-b0\_f));

estimate "Probability of zeroes in IN-IN" **1**/(**1** + exp(-b0\_f - b1\_f));

estimate "Probability of zeroes in IE-IE" **1**/(**1** + exp(-b0\_f - b2\_f));

estimate "N-N Sorensen" exp(b0\_h)(**1** - **1**/(**1** + exp(-b0\_f)));

estimate "IN-IN Sorensen" exp(b0\_h + b1\_h)(**1** - **1**/(**1** + exp(-b0\_f - b1\_f)));

estimate "IE-IE Sorensen" exp(b0\_h + b2\_h)(**1** - **1**/(**1** + exp(-b0\_f - b2\_f)));

estimate "Diff. in zero probability between N-N and IN-IN"

 **1**/(**1** + exp(-b0\_f - b1\_f)) - **1**/(**1** + exp(-b0\_f));

estimate "Diff. in zero probability between N-N and IE-IE"

 **1**/(**1** + exp(-b0\_f - b1\_f)) - **1**/(**1** + exp(-b0\_f));

estimate "Diff. in zero probability between IN-IN and IE-IE"

 **1**/(**1** + exp(-b0\_f - b1\_f)) - **1**/(**1** + exp(-b0\_f - b1\_f));

estimate "N-IN Sorensen diff"

 exp(b0\_h + b1\_h)(**1** - **1**/(**1** + exp(-b0\_f - b1\_f))) - exp(b0\_h)(**1** - **1**/(**1** + exp(-b0\_f)));

estimate "N-IE Sorensen diff"

 exp(b0\_h + b2\_h)(**1** - **1**/(**1** + exp(-b0\_f - b2\_f))) - exp(b0\_h)(**1** - **1**/(**1** + exp(-b0\_f)));

estimate "IN-IE Sorensen diff"

 exp(b0\_h + b1\_h)(**1** - **1**/(**1** + exp(-b0\_f - b1\_f)))- exp(b0\_h + b2\_h)(**1** - **1**/(**1** + exp(-b0\_f - b2\_f)));

**run**;

**data** expect\_zig;

set expect\_zig;

resid=Sorensen-Pred;

**run**;

**proc** **sgplot** data=expect\_zig;

scatter x=Pred y=resid;

**run**;

**SAS/STAT code to run discriminant analyses.** The following code was used to describe variation in plant community composition among leafy spurge invasion histories for the seed bank and vegetation.

**data** seed2007;

 set seed\_mv.seed07;

**run**;

**proc** **candisc** data=seed2007 all out=outcan;

 class current;

 var achmil andocc artfri broine carex chealb concan dessop dranem drarep echmur erapec eupesu eupspa hedhis linlew nasvir plapat poapra potentil taroff verbra;

**run**;

**proc** **template**;

 define statgraph scatter;

 begingraph;

 entrytitle 'Seed Bank 2007';

 layout overlayequated / equatetype=fit

 xaxisopts=(label='Canonical Variable 1')

 yaxisopts=(label='Canonical Variable 2');

 scatterplot x=Can1 y=Can2 / group=current name='seed2007';

 layout gridded / autoalign=(topright);

 discretelegend 'seed2007' / border=false opaque=false;

 endlayout;

 endlayout;

 endgraph;

 end;

**run**;

**proc** **sgrender** data=outcan template=scatter;

**run**;

**R code for calculating species similarities.** The following code was used to calculate species similarity values for the seed bank and vegetation data. The *vegdist* function is found in the ‘vegan’ package.

> seedcomp <- read.delim("C:/seed06&07.txt", header=T, row.names=1)

> seed.dist <- vegdist(seedcomp, method="bray", binary=TRUE, diag=TRUE, upper=FALSE, na.rm=FALSE)

#binary=TRUE converts the values into presence/absence (1/0) values before calculating the Jaccard index.#

> seed.dist.matrix <- as.matrix(seed.dist)

#This command converts the data frame to a matrix for exporting to a CSV file.#

> write.csv(seed.dist.matrix, file = "seeddist\_csv")

#This command writes the data to a CSV file and saves it to the hard drive.#

Appendix 2. Structure coefficients for seed bank and vegetation species. Bold values indicate influential species for the given canonical functions (Can1 and Can2), and dashes indicate that the species was not encountered in the given year. The guidelines for determination of species that were influential, and their correlations with specific invasion histories, are given in the methods. The second canonical functions for seed banks are not shown due to non-significant canonical correlation tests.

|  |  | Seed bank | Vegetation |
| --- | --- | --- | --- |
|  |  | 2006 | 2007 | 2007 | 2008 |
| Functional group | Species | Can1 | Can1 | Can1 | Can2 | Can1 | Can2 |
| exotic cool- | *Agropyron* sp. | - | - | - | - | 0.14 | 0.14 |
|  season grass | *Bromus inermis* | **0.47** | **0.24** | -0.47 | **0.03** | **0.47** | -0.03 |
|  | *Bromus japonicus* | - | - | 0.16 | **0.22** | -0.09 | 0.10 |
|  | *Poa compressa* | - | - | 0.00 | 0.29 | - | - |
|  | *Poa pratensis* | - | **0.55** | -0.50 | 0.18 | **0.44** | 0.08 |
| exotic forb | *Alyssum desertorum* | - | - | **-0.33** | **0.10** | 0.28 | 0.05 |
|  | *Brassica* sp. | - | - | **-0.37** | -0.18 | - | - |
|  | *Descurania sophia* | - | 0.34 | **0.35** | 0.03 | - | - |
|  | *Euphorbia esula* | **-0.23** | 0.44 | **-0.32** | -0.03 | **0.41** | 0.03 |
|  | *Medicago sativa* | - | - | **0.003** | -0.01 | - | - |
|  | *Melilotus officinalis* | - | - | **-0.30** | 0.10 | - | - |
|  | *Portulaca oleracea* | -0.11 | - | - | - | - | - |
|  | *Taraxacum officinale* | **-0.50** | **-0.17** | 0.19 | -0.41 | 0.11 | 0.16 |
|  | *Tragopogon dubius* | - | - | 0.44 | 0.33 | -0.33 | -0.08 |
| native cool- | *Hesperostipa comata* | - | - | **-0.24** | **0.12** | **0.13** | 0.14 |
|  season grass | *Hesperostipa spartea* | - | - | -0.02 | **0.07** | -0.03 | -0.03 |
|  | *Koeleria macrantha* | - | - | - | - | 0.03 | -0.06 |
|  | *Nassella viridula* | -0.21 | **-0.21** | **0.70** | **-0.25** | **-0.69** | **0.17** |
|  | *Pascopyron smithii* | -0.18 | - | 0.27 | -0.31 | -0.41 | -0.13 |
|  | *Vulpia octoflora* | - | - | 0.19 | -0.08 | - | - |
| native warm- | *Aristida purpurea* | - | - | - | - | **-0.09** | 0.29 |
|  season grass | *Bouteloua gracilis* | - | - | 0.47 | **-0.20** | -0.38 | **-0.25** |
|  | *Calamovilfa longifolia* | - | - | -0.20 | 0.16 | 0.50 | 0.16 |
|  | *Echinochloa muricata* | - | -0.09 | - | - | - | - |
|  | *Eragrostis pectinacea* | **-0.10** | 0.13 | - | - | - | - |
|  | *Muhlenbergia cuspidata* | - | - | - | - | -0.36 | **0.33** |
|  | *Schizachyrium scoparium* | - | - | - | - | 0.10 | 0.14 |
|  | *Sporobolus cryptandrus* | -0.08 | - | - | - | - | - |
| native sedge | *Carex* sp. | **0.17** | **0.27** | 0.31 | **0.10** | **0.35** | -0.03 |
|  | *Carex filifolia* | - | - | **-0.29** | **0.05** | -0.22 | **0.39** |
| native forb | *Achillea millefolium* | - | -0.09 | **0.34** | -0.10 | -0.25 | 0.09 |
|  | *Allium textile* | - | - | 0.39 | -0.07 | - | - |
|  | *Ambrosia psilostachya* | - | - | -0.29 | 0.09 | - | - |
|  | *Androsace occidentalis* | - | 0.42 | - | - | - | - |
|  | *Artemisia campestris* | - | - | -0.05 | **0.03** | - | - |
|  | *Artemisia frigida* | - | -0.13 | 0.33 | 0.14 | **-0.28** | **0.14** |
|  | *Asclepias* sp. | - | - | **-0.14** | 0.06 | - | - |
|  | *Asclepias verticillata* | - | - | -0.24 | 0.07 | -0.09 | **0.39** |
|  | *Astragalus* sp. | - | - | 0.18 | 0.15 | - | - |
|  | *Chamaesyce* sp. | - | - | - | - | -0.10 | -0.30 |
|  | *Chenopodium album* | - | -0.19 | - | - | 0.20 | -0.03 |
|  | *Conyza canadensis* | - | -0.04 | - | - | **0.34** | 0.06 |
| native forb | *Draba* sp. | - | - | 0.49 | **0.53** | - | - |
|  (cont.) | *Draba nemorosa* | - | 0.12 | - | - | - | - |
|  | *Draba reptans* | **0.35** | 0.33 | - | - | - | - |
|  | *Echinacea angustifolia* | - | - | 0.30 | 0.29 | 0.15 | 0.05 |
|  | *E. spathulata* or *Chamaesyce* sp. | - | - | 0.36 | 0.27 | - | - |
|  | *Euphorbia spathulata* | - | -0.03 | 0.14 | -0.16 | - | - |
|  | *Gaura coccinea* | - | - | 0.29 | **0.37** | - | - |
|  | *Hedeoma hispida* | - | 0.02 | 0.29 | 0.24 | - | - |
|  | *Helianthus* sp. | - | - | 0.04 | -0.27 | - | - |
|  | *Helianthus pauciflorus* | - | - | - | - | 0.20 | -0.01 |
|  | *Heterotheca villosa* | -0.02 | - | -0.04 | -0.10 | - | - |
|  | *Lactuca oblongifolia* | -0.30 | - | -0.08 | 0.12 | 0.30 | 0.06 |
|  | *Lappula occidentalis* | 0.09 | - | **0.42** | -0.01 | - | - |
|  | *Liatris* sp. | - | - | 0.13 | **-0.28** | - | - |
|  | *Linum lewisii* | - | **-0.14** | 0.31 | **0.15** | 0.07 | -0.06 |
|  | *Lygodesmia juncea* | - | - | - | - | 0.17 | 0.21 |
|  | *Packera plattensis* | - | - | 0.32 | **0.33** | - | - |
|  | *Pediomelum esculentum* | - | - | -0.13 | 0.17 | - | - |
|  | *Phlox hoodii* | - | - | 0.32 | -0.08 | -0.33 | **0.09** |
|  | *Plantago patagonica* | - | 0.18 | - | - | - | - |
|  | *Polygala alba* | - | - | 0.16 | **-0.06** | 0.05 | -0.08 |
|  | *Potentilla* sp. | **0.31** | **0.32** | - | - | - | - |
|  | *Ratibida columnifera* | - | - | 0.28 | -0.04 | - | - |
|  | *Senecio* sp. | - | - | **0.21** | 0.11 | - | - |
|  | *Solidago* sp. | - | - | **-0.06** | -0.10 | - | - |
|  | *Sphaeralcea coccinea* | - | - | 0.49 | -0.23 | **-0.58** | -0.02 |
|  | *Symphyotrichum ericoides* | - | - | 0.31 | 0.40 | 0.14 | -0.01 |
|  | *Tradescantia occidentalis* | - | - | **-0.21** | -0.01 | - | - |
|  | *Verbena bracteata* | **0.54** | 0.14 | - | - | - | - |
|  | *Vicia americana* | - | - | **-0.42** | 0.13 | - | - |
|  | *Viola nuttallii* | - | - | **0.35** | **-0.64** | - | - |
| native shrub | *Artemisia cana* | - | - | -0.11 | 0.04 | 0.41 | 0.05 |
|  | *Atriplex gardneri* | - | - | - | - | -0.17 | **-0.19** |
|  | *Escobaria* sp. | - | - | 0.18 | 0.07 | -0.06 | **0.20** |
|  | *Krascheninnikovia lanata* | - | - | 0.49 | **-0.39** | **-0.57** | **-0.14** |
|  | *Opuntia polyacantha* | - | - | -0.18 | -0.02 | - | - |
|  | *Symphoricarpos occidentalis* | - | - | -0.29 | 0.13 | 0.32 | 0.24 |

Appendix 3. Statistics for correlations between soil characteristics and seed banks / vegetation. Output is from generalized linear mixed models; only results from the most parsimonious models are shown. Tests of interactions with leafy spurge invasion history are identified by “×History” after the characteristic. Statistically significant effects via type III tests are shown in bold. Soil characteristics that did not help explain variation in the seed bank or vegetation data for particular year/month combinations are indicated by “-“. Degrees of freedom (DF) are shown as numerator/denominator; *F* = *F*-ratio and *P* = *P*-value.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  | Seed density / Vegetation cover | Species richness |
|  |  |  |  | Native | Exotic | Native | Exotic |
| Year | Variable | Characteristic | Month | DF | *F* | *P* | DF | *F* | *P* | DF | *F* | *P* | DF | *F* | *P* |
| 2007 | Seed bank | % Clay | June/July | 1/35 | 0.65 | 0.426 | 1/32 | 2.63 | 0.115 | - | - | - | - | - | - |
|  |  | % Clay×History | June/July | **2/35** | **14.73** | **<.001** | **2/32** | **4.26** | **0.023** | - | - | - | - | - | - |
|  |  | Net mineralization | June/July | - | - | - | **1/32** | **11.47** | **0.002** | - | - | - | 1/38 | 3.87 | 0.057 |
|  |  |  | Aug./Sep. | **1/35** | **31.36** | **<.001** | 1/32 | 0.01 | 0.934 | 1/42 | 0.11 | 0.738 | - | - | - |
|  |  | Net min.×History | June/July | - | - | - | **2/32** | **6.4** | **0.005** | - | - | - | - | - | - |
|  |  | Net nitrification | June/July | **1/35** | **7.62** | **0.009** | **1/32** | **11.7** | **0.002** | - | - | - | **1/38** | **5.75** | **0.022** |
|  |  |  | Aug./Sep. | **1/35** | **29.01** | **<.001** | - | - | - | - | - | - | 1/38 | 0.29 | 0.592 |
|  |  | Net nit.×History | June/July | **2/35** | **15.87** | **<.001** | **2/32** | **6.01** | **0.006** | - | - | - | - | - | - |
|  |  | Phosphorus | June/July | **1/35** | **5.18** | **0.029** | 1/32 | 2.42 | 0.129 | 1/42 | 0 | 0.993 | 1/38 | 1.63 | 0.21 |
|  | Vegetation | % Sand | June/July | - | - | - | **1/40** | **10.67** | **0.002** | **1/38** | **6.67** | **0.014** | - | - | - |
|  |  | pH | June/July | - | - | - | 1/40 | 0.07 | 0.797 | 1/38 | 1.34 | 0.255 | - | - | - |
|  |  | pH×History | June/July | - | - | - | **2/40** | **34.93** | **<.001** | **2/38** | **20.71** | **<.001** | - | - | - |
|  |  | Net mineralization | June/July | **1/39** | **25.7** | **<.001** | - | - | - | - | - | - | - | - | - |
|  |  |  | Aug./Sep. | **1/39** | **7.89** | **0.008** | - | - | - | 1/38 | 0.58 | 0.453 | 1/41 | 3.27 | 0.078 |
|  |  | Net min.×History | June/July | **2/39** | **15.45** | **<.001** | - | - | - | - | - | - | - | - | - |
|  |  | Net nitrification | June/July | **1/39** | **26.82** | **<.001** | **1/40** | **12.93** | **<.001** | - | - | - | - | - | - |
|  |  |  | Aug./Sep. | **1/39** | **7.93** | **0.008** | **1/40** | **10.42** | **0.003** | - | - | - | 1/41 | 2.84 | 0.1 |
|  |  | Net nit.×History | June/July | **2/39** | **13.82** | **<.001** | - | - | - | - | - | - | - | - | - |
|  |  |  | Aug./Sep. | - | - | - | **2/40** | **8.54** | **<.001** | - | - | - | - | - | - |
|  |  | Phosphorus | June/July | - | - | - | - | - | - | 1/38 | 0.15 | 0.705 | 1/41 | 0.11 | 0.747 |
| 2008 | Vegetation | Net mineralization | June/July | - | - | - | - | - | - | **1/43** | **7.34** | **0.01** | 1/37 | 0.96 | 0.333 |
|  |  |  | Aug./Sep. | - | - | - | **1/25** | **5.23** | **0.031** | - | - | - | - | - | - |
|  |  | Net min.×History | June/July | - | - | - | - | - | - | - | - | - | **2/37** | **3.84** | **0.031** |
|  |  |  | Aug./Sep. | - | - | - | **2/25** | **4.93** | **0.016** | - | - | - | - | - | - |
|  |  | Net nitrification | June/July | 1/44 | 1.93 | 0.172 | - | - | - | - | - | - | 1/37 | 1.05 | 0.312 |
|  |  | Net nit.×History | June/July | - | - | - | - | - | - | - | - | - | **2/37** | **4.15** | **0.024** |
|  |  | Phosphorus | June/July | 1/44 | 3.72 | 0.06 | 1/25 | 0.34 | 0.563 | 1/43 | 0.79 | 0.38 | 1/37 | 0.07 | 0.793 |