microstegium_elymus_model_ideas

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Summary

Simulation of *Microstegium vimineum* and *Elymus virgincus* over time. *M. vimineum* is an invasive annual grass and *E. virginicus* is a native perennial grass. *E. virginicus* grows by itself for 100 years, and then *M. vimineum* is introduced. Disease effects arise 100 years later. Population dynamics are similar in the absence of disease and when both species are susceptible to disese. In both cases, *M. vimineum* reduces the size of the *E. virginicus* population. *M. vimineum* is able to recover population losses due to disease. *E. virginicus* seedlings are impacted more than adults. When only *M. vimineum* is susceptible to disease, its population crashes.

Parameters

- subscripts follow "."
- p = perennial adult (at least 1 year old)
- s = perennial seedling (germinated that spring)
- a = annual
- L = annual litter

Table 1: Model parameter values

parameter	symbol	value	units	reference
perennial adult survival	m.p	0.9500	year^{-1}	Malmstrom et al. 2005
annual seed survival	s.a	0.7400	year^{-1}	Huebner 2011
perennial seed survival	s.s	0.7600	year^{-1}	Robocker et al. 1953
annual germination	gamma.a	0.7000	year^{-1}	Warren et al. 2013
perennial germination	gamma.s	0.6600	year^{-1}	Robocker et al. 1953
litter suppression of annual germination	alpha.aL	-0.0009	g^{-1} year^{-1}	Foster and Gross 1998
litter suppression of perennial germination	alpha.sL	-0.0009	g^{-1} year^{-1}	Foster and Gross 1998
litter decomposition rate	b	0.5800	year^{-1}	Kourtev et al. 2002
annual summer survival	h.a	0.9500	year^{-1}	Warren et al. 2013
perennial seedlingsummer survival	h.s	0.4000	year^{-1}	Mottl et al. 2006
perennial adult summer survival	h.p	0.8300	year^{-1}	Mottl et al. 2006
annual seed production	lambda.a	6500.0000	seeds year^{-1}	Wilson et al. 2015
perennial seed production	lambda.p	435.0000	seeds year^{-1}	Stevens 1957
annual-annual competition	alpha.aa	0.1220	year^{-1}	Leicht et al. 2005
seedling-annual competition	alpha.as	0.3570	year^{-1}	Leicht et al. 2005
seedling-seedling competition	alpha.ss	0.0020	year^{-1}	Leicht et al. 2005
annual-seedling competition	alpha.sa	0.7240	year^{-1}	Leicht et al. 2005
biomass-seed conversion	c.a	0.0050	g seeds^{-1} year^{-1}	Wilson et al. 2015
disease suppression of annual seed production	tol.a	0.1900	year^{-1}	Flory et al. 2011
disease suppression of perennial seed production	tol.p	0.1900	year^{-1}	Flory et al. 2011
annual-adult competition	alpha.pa	0.0724	year^{-1}	derived
seedling-adult competition	alpha.ps	0.0724	year^{-1}	derived
adult-annual competition	alpha.ap	3.5700	year^{-1}	derived
adult-seedling competition	alpha.sp	3.5700	year^{-1}	derived
adult-adult competition	alpha.pp	3.5700	year^{-1}	derived

parameter	symbol	value	units	reference
seedling seed production	lambda.s	43.5000	seeds $year^{-1}$	derived

Table 2: Alternative model parameter values

parameter	symbol	value	units	reference
annual germination	gamma.a	0.29	$year^{-1}$	Huebner 2011
annual intraspecific seed competition	alpha.aa	0.001, 0.015, 0.054	$year^{-1}$	Leicht et al. 2005
annual interspecific competition	alpha.as	0.054, 0.910, 17.919	$year^{-1}$	Leicht et al. 2005
perennial intraspecific competition	alpha.ss	0.006, 0.011, 0.049	$year^{-1}$	Leicht et al. 2005
perennial interspecific seed competition	alpha.sa	1.347, 9.574, 23.070	$year^{-1}$	Leicht et al. 2005
disease suppression of seed production	tol	0.6	$year^{-1}$	Stricker et al. 2016

Model

Population equations:

Assume counts are being conducted in the fall

N.s[t+1] = s.s * (1-g.s) * N.s[t] + g.s * h.s * f.s * N.s[t] + m.p * f.p * N.p[t]
perennial seeds = seed bank survival + seedling seed production + adult seed production
seedling survival seems to be density-dependent (intraspecific facilitation, interspecific competition)

N.p[t+1] = m.p * N.p[t] + g.s * h. s * N.s[t]
perennial adults = survival + seedling maturation

N.a[t+1] = s.a * (1-g.a) * N.a[t] + g.a * h.a * f.a * N.a[t]
annual seeds = seed bank survival + seed production
seed survival or germination seems to depend on infection

L[t+1] = c.a * g.a * h.a * N.a[t] + L[t] * e^{-b}
annual litter = biomass from previous fall + decomposition
c.a is probably a function of density

Density-dependence on fecundity

f.s = lam.s / (1 + alpha.ss * g.s * h.s * N.s[t] + alpha.sp * m.p * N.p[t] + alpha.sa * g.a * h.a * N.a[t])
perennial seedling fecundity = fecundity in the absence of competition / (perennial seedling competition + perennial adult competition + annual competition)

f.p = lam.p / (1 + alpha.ps * g.s * h.s * N.s[t] + alpha.pp * m.p * N.p[t] + alpha.pa * g.a * h.a * N.a[t])
perennial adult fecundity = fecundity in the absence of competition / (perennial seedling competition + perennial adult competition + annual competition)

f.a = lam.a / (1 + alpha.as * g.s * h.s * N.s[t] + alpha.ap * m.p * N.p[t] + alpha.aa * g.a * h.a * N.a[t])
annual fecundity = fecundity in the absence of competition / (perennial seedling competition + perennial adult competition + annual competition)
we don't currently have good estimates for competition coefficients
density-dependence of fecundity changes with infection

Litter suppression

g.s = gamma.s + (alpha.sL * L[t])
perennial seed germination = germination in the absence of litter + reduction due to litter (alpha.sL < 0, g.s constrained to >= 0)

g.a = gamma.a + (alpha.aL * L[t])
annual seed germination = germination in the absence of litter + reduction due to litter (alpha.aL < 0, g.a constrained to >= 0)
litter production is correlated with more cleistogamous seeds in the first year