Predicting Woody Plant Invasiveness Using Seedling Growth Traits and Performance Under Varying Drought and Nitrogen Levels

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Which life history traits are more common in invasive species?

- Short juvenile period, small seed size, relative growth rate (RGR) and allocation traits such high specific leaf area (SLA) and high leaf area ratio (LAR) characterize invasive pines (Rejmánek 1996; Grotkopp, Rejmánek & Rost 2002)

- RGR higher under high N for invasive species in the Commeliaceae family (Burns 2004)

- RGR and SLA were significantly higher for invasives in a broad range of woody dicot families (Grotkopp & Rejmánek 2007)

How invasive species arrive

- Contaminants
- Horticulture

Photos from DiTomaso and Healy 2007

How have life history traits been used to screen for invasiveness?

- Reichard & Hamilton 1997; Reichard & White 2001)
- Discriminant Z scores: Rejmanek 1996; Rejmanek and Richardson 1996
- Weed Risk Assessment (Pheloung et al. 1999; Daehler et al. 2004)

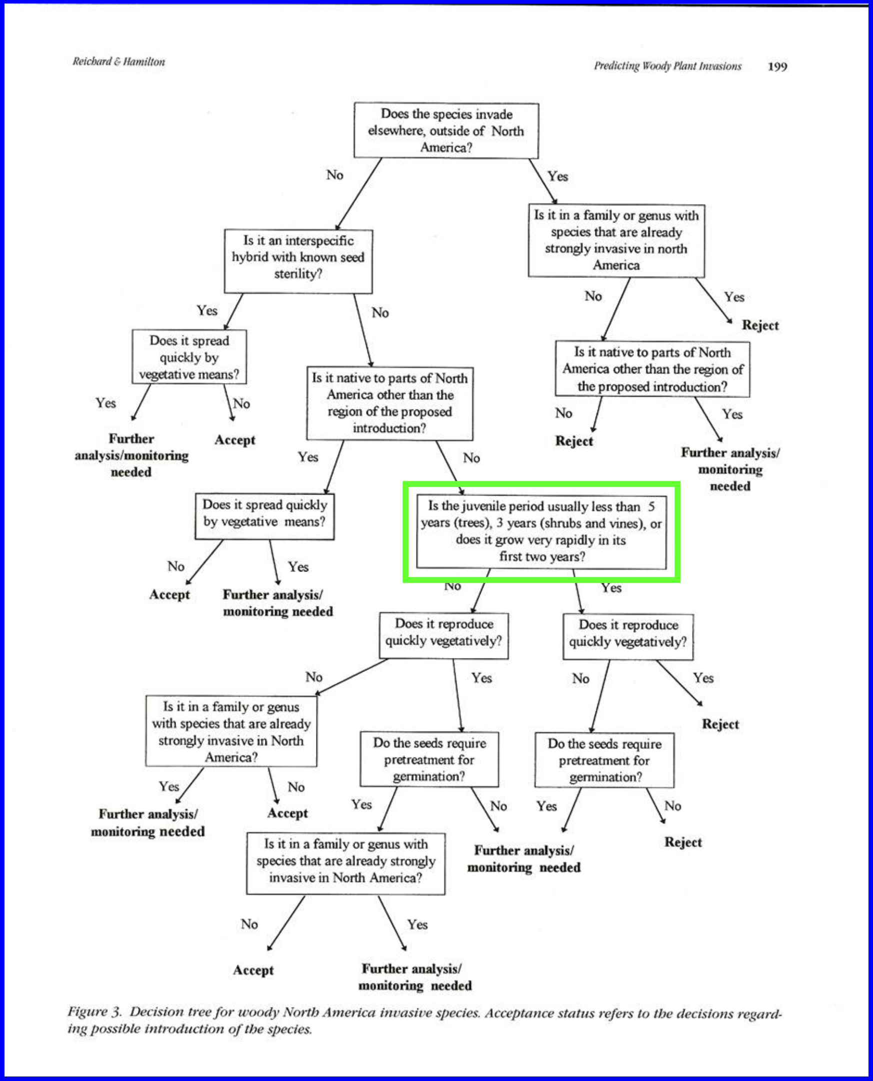


Figure 3. Decision tree for woody North America invasive species. Acceptance status refers to the decisions regarding possible introduction of the species.

Species Selection

- All species chosen were found in Sunset Western Garden Book (commonly used woody hort species- all exotic).
- Invasive species chosen are invaders in California or other mediterranean climates.
- Less invasive species have similar growth form to invasive counterpart, and are potential alternatives to invasive species.
- Invasive and less invasive species were set up as phylogenetically independent contrasts.

Genista aethnensis was our less invasive species contrasting with the invasive *Cytisus scoparius*

Small pot experiment

- All species grown under ambient conditions (full water/nutrients/light in the greenhouse)
- Seedlings harvested at 10, 20, and 30 days after emergence
- Plants were separated into cotyledons, leaves, stems, and roots;
- Leaf area was calculated; plant parts were dried and weighed separately

Growth analyses

RGR=NAR*LAR

LAR=SLA*LMR

- RGR=Relative growth rate (mg/g/day)
- NAR= Net assimilation rate (mg/cm^2/day)
- LAR= Leaf area ratio (cm$^2_{leaf}$/g$_{plant}$)
- SLA= Specific leaf area (cm$^2_{leaf}$/g$_{leaf}$)
- LMR= Leaf mass ratio (g$_{leaf}$/g$_{plant}$)
- R/P= Root/plant ratio (g$_{root}$/g$_{plant}$)

Contrasts used in first 2 experiments

Family	Invasive	Less invasive
Fabaceae1	*Acacia dealbata*	*A. pendula*
Fabaceae2	*Albizia julibrissin*	*Ceratonia siliqua*
Fabaceae3	*Robinia pseudoacacia*	*Cercis canadensis*
	Sesbania punicea	
Fabaceae4	*Acacia cyclops*	*A. pendula*
	A. melanoxylon	
Fabaceae5	*Acacia saligna*	*A. cultriformis*
Fabaceae6	*Spartium junceum*	*Genista hispanica*
	Ulex europaeus	*Genista aethnensis*
	Retama monosperma	*Genista tictoria*
	Genista monspessulana	
	Cytisus scoparius	
Moraceae1	*Ficus carica*	*Maclura pomifera*
Moraceae2	*Morus alba*	*M. rubra*
Myrtaceae1	*Eucalyptus camaldulensis*	*E. leucoxylon*
Myrtaceae2	*Eucalyptus cladocalyx*	*E. nicholii*
	E. lehmannii	
Myrtaceae3	*Eucalyptus camaldulensis*	*E. pulverulenta*
		E. viminalis
Oleaceae	*Fraxinus velutina*	*Syringa vulgaris*
Rosaceae1	*Cotoneaster lacteus*	*Photinia serrulata*
Rosaceae2	*Rubus armeniacus*	*R. idaeus*
Roseaceae3	*Rosa multiflora*	*R. glauca*
Sapindaceae	*Acer ginnala*	*A. truncatum*
Apocynaceae	*Nerium oleander*	*Thevetia peruviana*
Buddlejaceae	*Buddleja davidii*	*B. globosa*

Contrasts used this year

Family	Invasive	Less invasive
Anacardiaceae	*Schinus molle*	*Rhus lancea*
	S. terebinthefolius	
Berberidaceae	*Berberis thunbergii*	*B. koreana*
Caesalpiniaceae	*Caesalpinia pulcherimma*	*C. cacalaco*
	C. gillesii	
Papilionaceae	*Erythrina crista-galli*	*E. corralloides*
Myrtaceae	*Eucalyptus camaldulensis*	*E. pauciflora*
	E. globulus	*E. macrocarpa*
	E. lehmanii	*E. bauriana*
Myrtaceae	*Leptospermum laevigatum*	*L. lanigerum*
Lamiaceae	*Lavandula stoechas*	*L. angustifolia*
Rosaceae1	*Eriobotrya japonica*	*E. deflexa*
Rosaceae2	*Pyrus calleryana*	*P. salicifolia*

Total families: 13

Total contrasts: 27

Results of the first 2 years

- Growth traits were analyzed with 1-tailed paired *t* tests (n=17)

- Invasive species have significantly higher:

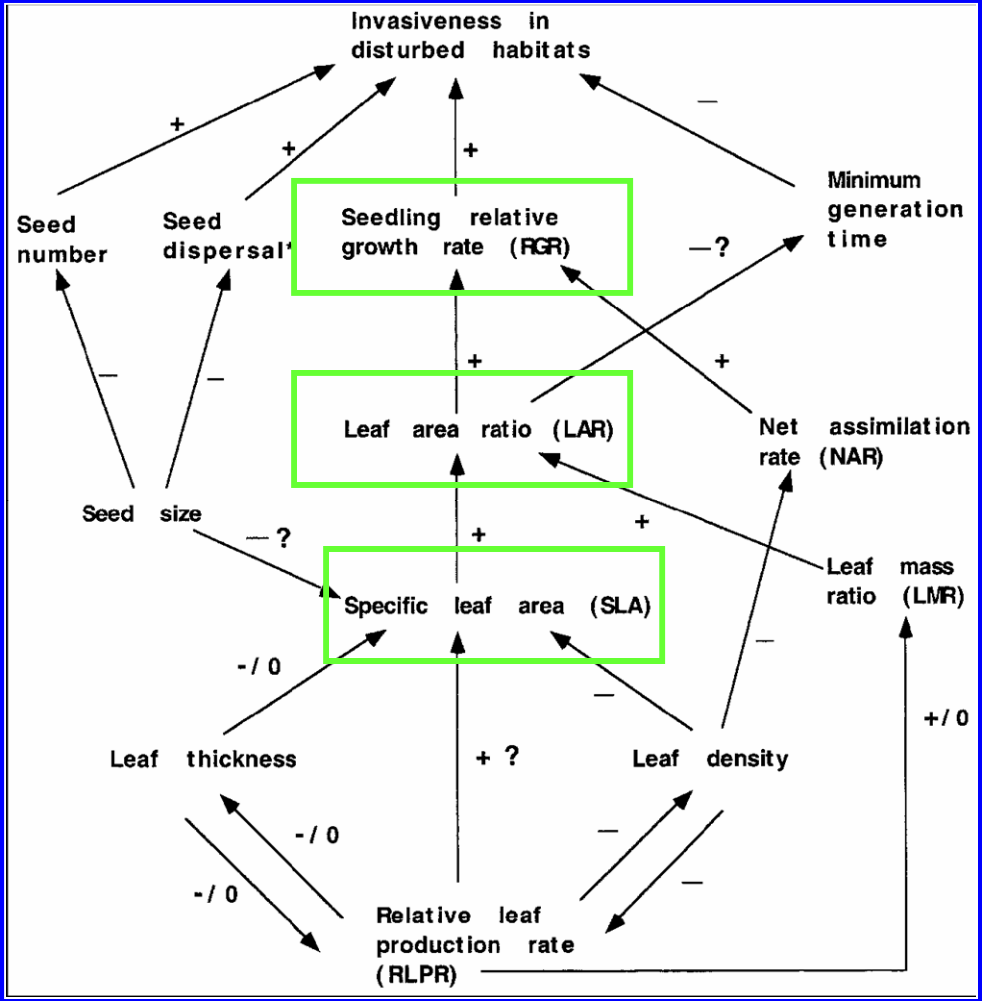
  RGR ($p<0.05$)

  LAR ($p<0.01$)

  SLA ($p<0.01$)

Conclusion

- Leaf architecture (SLA), allocation patterns (LAR), and RGR seem to play important roles in the level of plant invasiveness under non-stressful growth conditions.



From Grotkopp et al. 2002

Nitrogen and drought experiment

- Increased nitrogen deposition through smog and other pollution (atmospheric N).
- Increased drought levels in California with global warming.
- Are there differences in how invasive and non-invasive species respond to potential global climate change, i.e. drought, and/or increased nitrogen levels?

Methods

- Plants grown under full water and either low or high N for 60 days.
- Plants were then assigned to 1 of 3 drought treatments (low, medium, high).
- Pigment analysis performed at 10 day intervals from 60-90 days.
- Plants harvested at 90 days.

Results- pigment analysis

- Invasive species had a much higher chlorophyll content than non-invasive species under high N conditions ($p<0.01$).
- Therefore invasive species are more opportunistic in using available nitrogen for photosynthesis and likely growth.

Further analyses

- Continue multivariate analysis for universal traits of invasiveness while controlling for phylogeny.
- Look within angiosperm lineages for alternative strategies for invasiveness within clades.

2007 changes to nitrogen/drought study

- Plants grown for 30 days under full water and high or low nitrogen (vs. 60 days).
- Watering interval increased from 2, 4, 8 days between watering to 3, 6, 12 days.
- Final harvest 45 days after drought began (vs. 30 days).
- Root analyses performed on a subset of species under low and high nitrogen.

Implications of research– when little is known about a species….

Much known about a species

- Weed Risk Assessment (Australia/NZ)
- Cal-IPC weed inventory
- Climax modeling

Little known about a species

- Growth analyses with related species of known invasiveness

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