Is the presence of invasive species related to species richness and species composition?

I am interested in looking at the relationship between nonnative invasive species presence and diversity and between invasive species presence and species composition. Nonnative species are nonnative at the level of a floristic province. Invasive species spread rapidly and displace native species and natural habitats (CalEPPC 2001). Nonnative invasive species have a potential to disproportionately influence the areas they occur in when compared to noninvasive species. These influences may include (and are not limited to) richness and species composition. Measures of invasive species presence (or invasion) could be related to richness by lowering richness through competition and exclusion of other species, invasive species could add to richness or areas with varying richness could be more or less susceptible to invasion. The presence of invasive species may also be related to species composition. Individual species may be more or less likely to occur in the same sampling unit as an invasive species due to exclusion by the invader or an invasive species may prefer different habitat characteristics. Invasive presence, richness and species composition can be measured at multiple scales. Relationships between these variables could potentially occur at multiple scales.

I started with McLaughlin and will expand to include other research sites. For McLaughlin, all analyses are done separately for serpentine and nonserpentine soils and both separately and collectively for all years. At McLaughlin, nonnative invasive species can be measured in several ways at three scales. At the scales of plot (1m2), transect (5-1m2 plots) and study site (all transects) we can find: presence/ absence of any invader, number of invasive species and presence/ absence of each invasive species. At the transect level, 'invadideness' can be measured by the percentage of plots in the transect that contain an invader and the percentage of plots in the transect that contain each invasive species. So the relationship between measures of invasion and richness can be studied with regressions between the each of the values of richness and measures of invasion with all invasive species combined and each invasive species individually. The relationship between presence of invasion and species composition can be studied with a similarity matrix too see if the presence of invaders is related to the presence of other species.

These analyses could be expanded in several ways. All analyses should be repeated using native species richness instead of total species richness. I plan to do similar analyses with native invasive species and at other study sites. It would be interesting to look at data for which a time series is available. If an invasive species appears in a sampling unit for which it previously did not occur, are the richness and composition different from sampling units that were not invaded?

Definition of 'Invasive'

I used the 'nonnative invasive species' classifications developed by CalEPPC guidelines, published by the California Ag Council. According to CalEPPC guidelines, invasive species spread rapidly, displace native species and natural habitats. Nonnative species are those that are outside of their "natural range and dispersal potential". CalEPPC makes several divisions of nonnative invasive species that could be combined or separated: Most invasive (subdivided into widespread and regional pests), lesser invasiveness, red alert and annual grasses. A total of 11 species on all CalEPPC lists occur in the sampled plots at McLaughlin (excluding species in the categories 'Need More Information' and 'Considered But Not Listed'). I will also classify native species as native invasive using the criteria from CalEPPC (except for nativity) and information from the Jepson manual to compare relationships found with nonnative invasives with native invasives. CalEPPC guidelines apply only to California. Expanding these analyses to research sites outside of California will require either finding equivalent classifications for the region in which the research site occurs or use species descriptions to classify species as non-native to a floristic region and invasive.

McLaughlin Invasive Spp

Regressions between richness and measures of invasion at multiple scales

	Year	Nonserp	Serp
Rich 5m2 v. No.invasives 5m2	1998	ns	ns
	1999	ns	ns
	2000	+	ns
	All	+	ns
Rich 1m2 v. No.invasives 1m2	1998	ns	ns
	1999	ns	ns
	2000	+	ns
	All	+	+
Richness 5m2 v. 'Invadedness' 5m2	1998	ns	ns
	1999	ns	ns
	2000	ns	ns
	All	ns	ns
Richness1m2 v. Invadedness' 5m2	1998	ns	ns
	1999	ns	ns
	2000	ns	ns
	All	ns	ns

Invadedness' = % of 1m2 plots that are invaded in a transect
NS= Not significant at 0.05

To Do:
Above for each of 11 invasive spp.
Similarity index (plots within a transect, in different transects)

Total richness is compared in sampling units where each invader is present and absent using ANOVA.

	Species	Community T	1998	1999	2000	All Years	
Rich_5m2	Ta_ca	N	NS	NS	NS	NS	
	Ta_ca	S	-	**0.0009**	NS	NS	
	Br_ma	N	NS	NS	NS	NS	
	Br_ma	S	NS	NS	NS	NS (0.0837)	
	Be_tr	N	-	-	-	-	
	Be_tr	S	-	-	-	-	
	Ca_py	N	-	NS	-	NS	*
	Ca_py	S	-	-	-	-	
	Ci_vu	N	-	NS	-	NS	*
	Ci_vu	S	-	-	-	-	
	Ae_tr	N	-	-	-	-	
	Ae_tr	S	-	-	NS	NS	*
	Av_ba	N	NS	-	-	NS	*
	Av_ba	S	NS	NS	NS	NS	*
	Av_fa	N	NS	NS	**0.0275**	NS	
	Av_fa	S	NS	NS	NS	**0.0262**	
	Bra_dis	N	NS	-	-	NS	*
	Bra_dis	S	NS	-	-	NS	*
	Br_dia	N	NS	NS (0.0570	NS (0.0676	NS	
	Br_dia	S	-	NS	-	NS	
	Lo_mu	N	NS	NS	-	NS	
	Lo_mu	S	NS	-	-	NS	*

Rich_1m2	Ta_ca	N	NS	NS	NS	NS (0.0532)	
	Ta_ca	S	-	**0.0006**	NS	**<0.0001**	
	Br_ma	N	NS	NS	NS (0.0657	**0.0062**	
	Br_ma	S	NS (0.0598	NS (0.1057	NS (0.1019	NS (0.0673)	
	Be_tr	N	-	-	-	-	
	Be_tr	S	-	-	-	-	
	Ca_py	N	-	NS	-	NS	*
	Ca_py	S	-	-	-	-	
	Ci_vu	N	-	NS	-	NS	*
	Ci_vu	S	-	-	-	-	
	Ae_tr	N	-	-	-	-	
	Ae_tr	S	-	-	NS (0.1053	NS	*
	Av_ba	N	NS	-	-	NS	
	Av_ba	S	NS	NS	NS	NS	*
	Av_fa	N	NS	NS	NS	NS	
	Av_fa	S	NS	NS	NS	NS	
	Bra_dis	N	NS (0.0673	-	-	NS	*
	Bra_dis	S	NS	-	-	NS	*
	Br_dia	N	NS	**0.0452**	NS	**0.006**	
	Br_dia	S	-	NS	-	**0.0036**	
	Lo_mu	N	NS	NS	-	NS	
	Lo_mu	S	NS	-	-	NS	

For all significant values (except Av_fa in S, 2000) the richness of the invaded sampling units is greater than the richness of the noninvaded sampling units
If significant, p is given
NS= Not significant at 0.05
(-) = No species occurrences
* = species occurs in <5% sampling units

Attempts to relate ecological patterns and the mechanisms driving these patterns are hindered by the lack of overarching and integrated programs for the collection of relevant data (Huston 1999). Programs to collect or archive specific measurements abound (e.g., FLUXNET, ORNL DAAC), but our ability to combine these data in meaningful ways is severely constrained by mismatches between the spatio-temporal domains of data collected to identify patterns and those collected to determine causation. Even programs that attempt to address these issues at local scales (e.g., LTER) are less consistent about matching the domains of measurements across sites. The inadequacy of existing data to address controls on the generation and maintenance of biodiversity led Huston (1999) to comment that "the number of hypotheses about species diversity far outstrips the data that are available to test these hypotheses." Our present ad hoc approach to the collection of ecological data needs to be closely examined in the light of proposed major investments in infrastructure to enhance measurement and monitoring of ecological processes.

Chase and Leibold (2002) present an example of the importance of matching measurement domains. Data that they collected from small ponds showed a hump-shaped relationship between productivity and species richness when viewed at a local scale (among ponds). However, the same data viewed at a regional scale (among watersheds) produced a positive linear relationship, suggesting that the mechanisms that produce patterns are scale dependent. These results confirm earlier studies in lakes (Dodson et al. 2000) and grasslands (Gross et al. 2000). However, in the grassland study, linear patterns were found at the local scale and humped patterns at larger scales. Searching for similar or conflicting patterns in other systems is hampered by the lack of matching measurement domains, which restricts our ability to examine the effects of scale the relationship between dependent and independent variables.

Thompson et al. (2001) indicated that defining the spatial-temporal domains of ecological processes was one of the most important issues in ecology, one that would require a reevaluation of the way ecologists bound their conceptual models. The existence of a set of domains of causality that vary in spatial and temporal extent complicates these models and requires a clear topology of ecological causative factors (Thompson et al. 2001). Once this topology is established, measurements protocols need to be instituted to assure that relevant data are collected for each domain. Since different kinds of ecological questions might require data from different measurement domains, the establishment of new monitoring programs will require careful attention to matching key ecological questions with long-term measurements.