

**SPATIAL VARIATIONS OF THE INVASIBILITY OF
SLASH PINE FLATWOODS TO CHINESE TALLOW
(*Triadica sebifera*) INVASION: MECHANISMS AND
KEY FACTORS AT THE MICROSCALE**

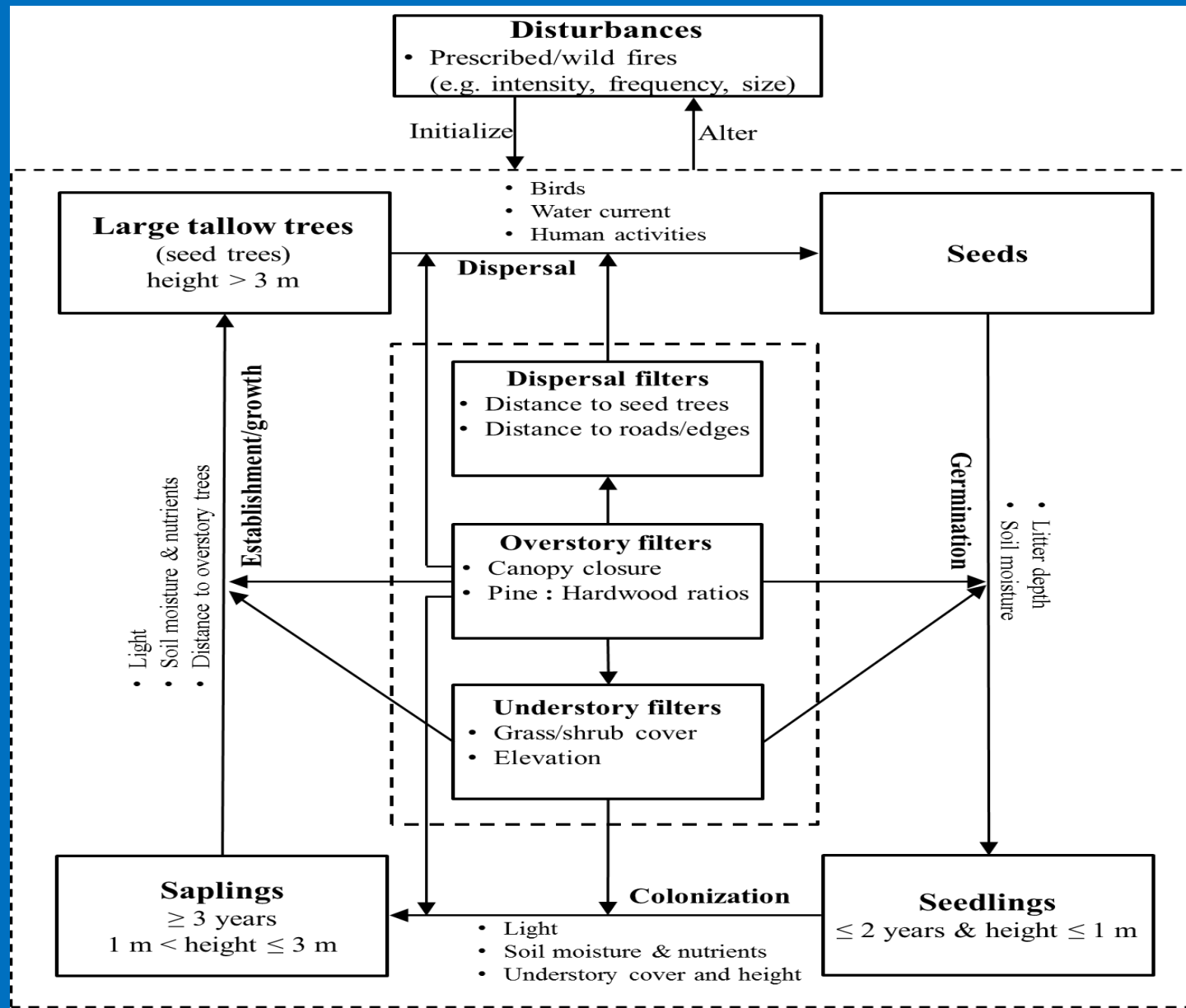
Fan, Shaoyang Yang, Nancy Loewenstein, Nannan Cheng,
and Sunil Nepal

School of Forestry and Wildlife Sciences, Auburn University,
Auburn, AL 36849

Definition of ecosystem invasibility

- In invasion ecology, the term ‘invasibility’ has been coined to describe the susceptibility (an intrinsic property) of recipient ecosystems to invasive species, a manifestation of the interactions of multiple processes and factors (Lonsdale 1999)
- The invasibility of an ecosystem to biological invasion is determined by its structure, local disturbance, propagule pressure level, and the biological traits of the invasive species (Davis et al. 2000).
- As for a specific invasive species such as Chinese tallowtree (*Triadica sebifera*), the invasibility of an ecosystem can be quantified by its community-landscape structure, propagule pressure and disturbance/stress regime (Alpert et al. 2000, Davis et al. 2000, D’Antonio et al. 2001).

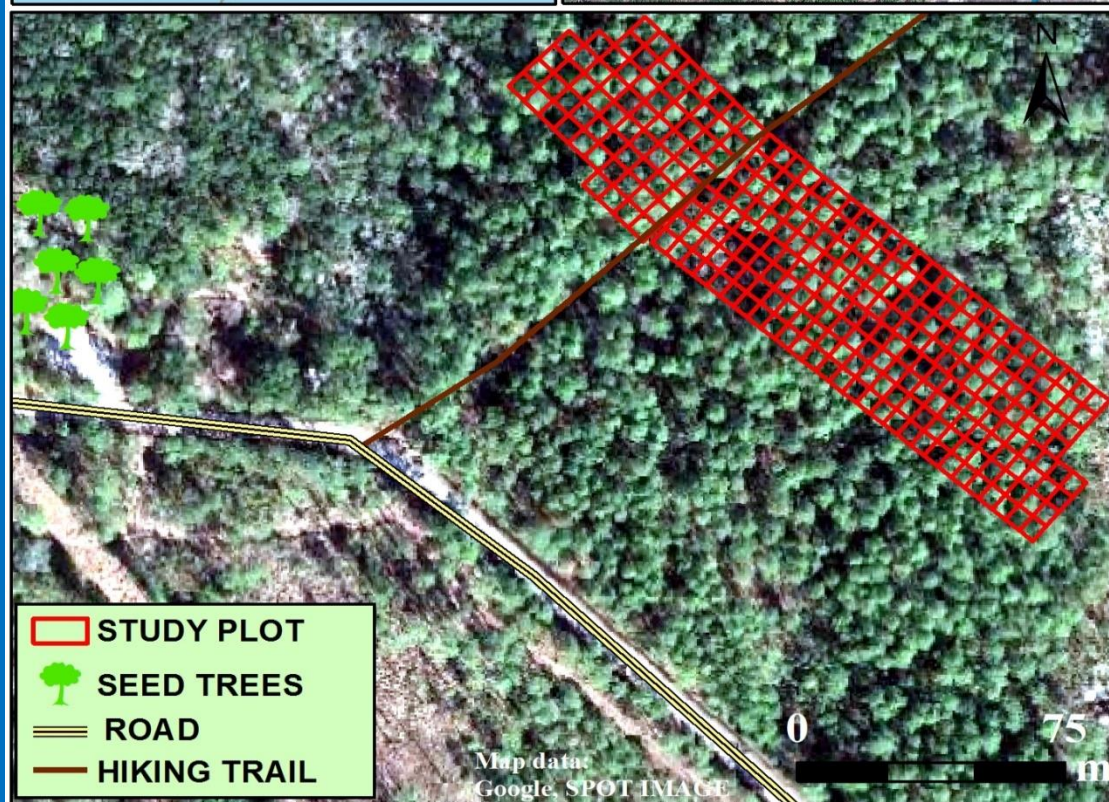
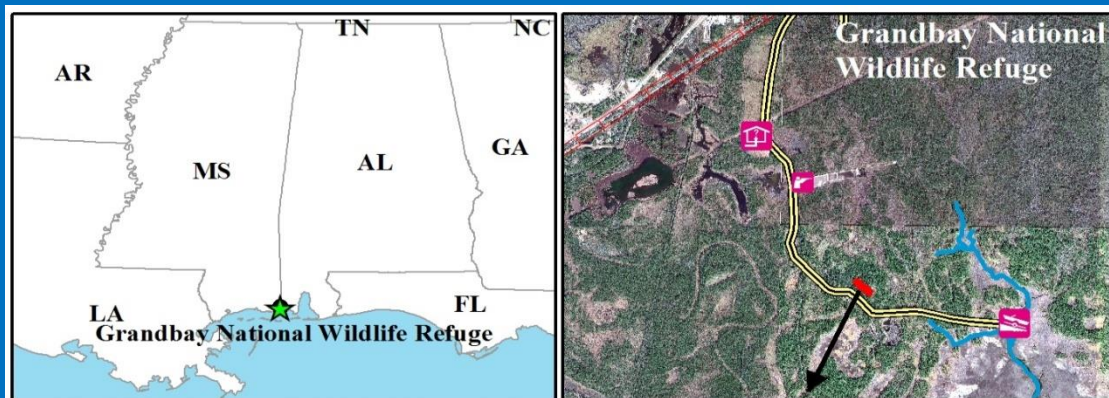
The conceptual diagram of tallow invasion at the micro scale showing the filters that affect tallow invasion processes



A case study: Tallow tree invasion in the Grand Bay National Wildlife Refuge (GBNWR)

GBNWR is

- A landscape of ~18,000 ac dominated by longleaf/slash pine flatwoods and savannas.
- Other ecosystems include salt marshes, maritime forest, wetlands, and bays.



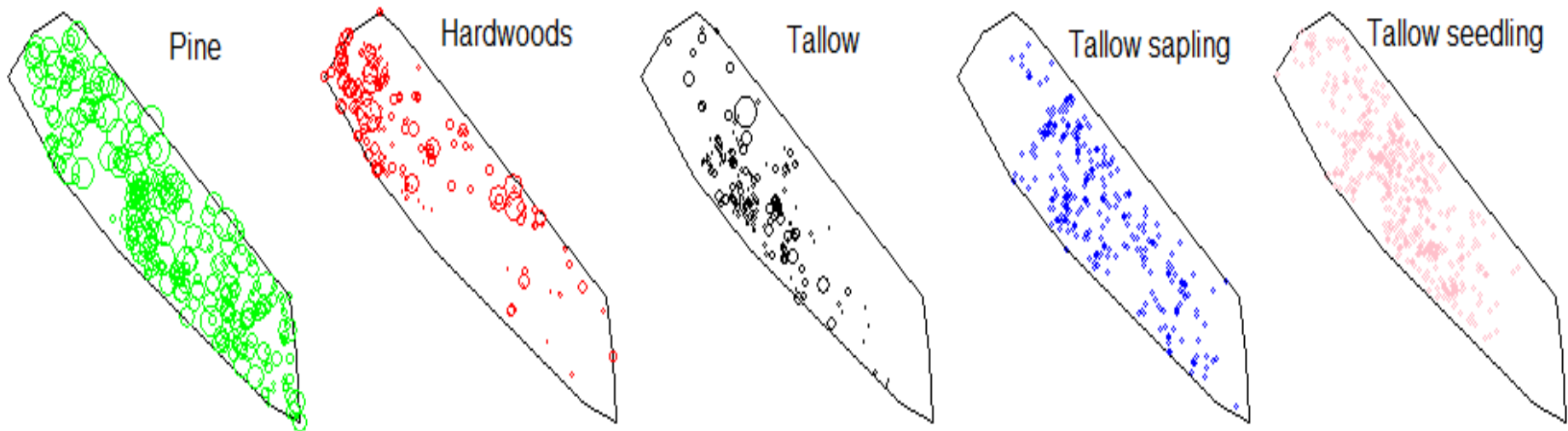
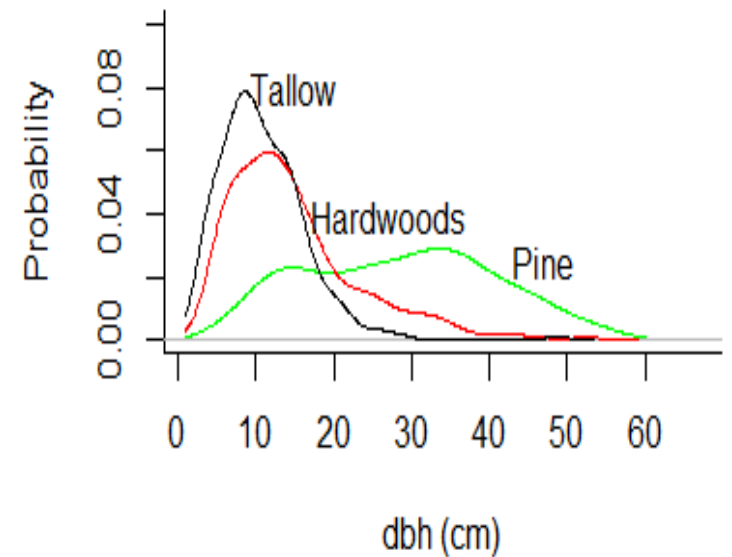
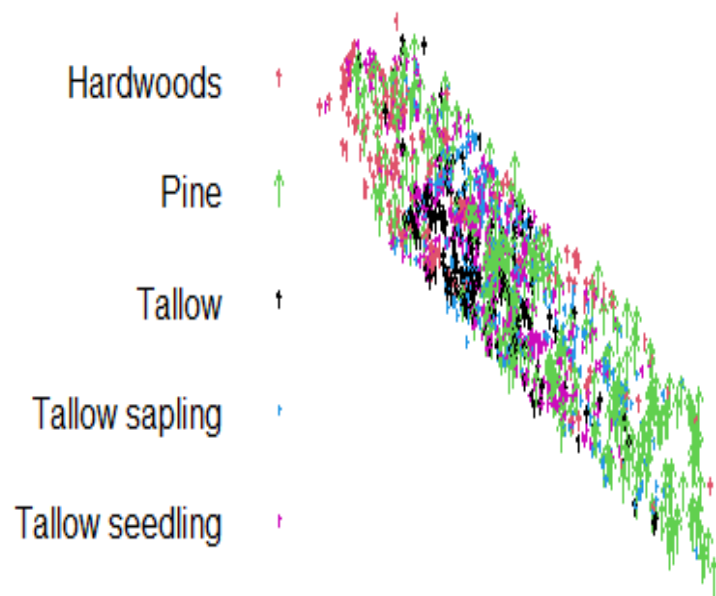
Data collection/preparation

- The plot was then divided into a grid of contiguous quadrats of $\sim 30 \text{ m}^2$ in size ($n = 281$).
- The species and dbh, if present, of all mapped trees ($n = 2,190$) using a high-resolution GPS device were measured and recorded.
- The raster data of six filters including distance to the nearest seed trees, distance to the nearest road or the hiking trail, overstory canopy closure (%), basal area ratio of pine to hardwoods, understory grass coverage (%), and elevation (microtopographic condition) were generated to predict spatially-varying probability of tallow invasion by size class (trees, saplings and seedlings)

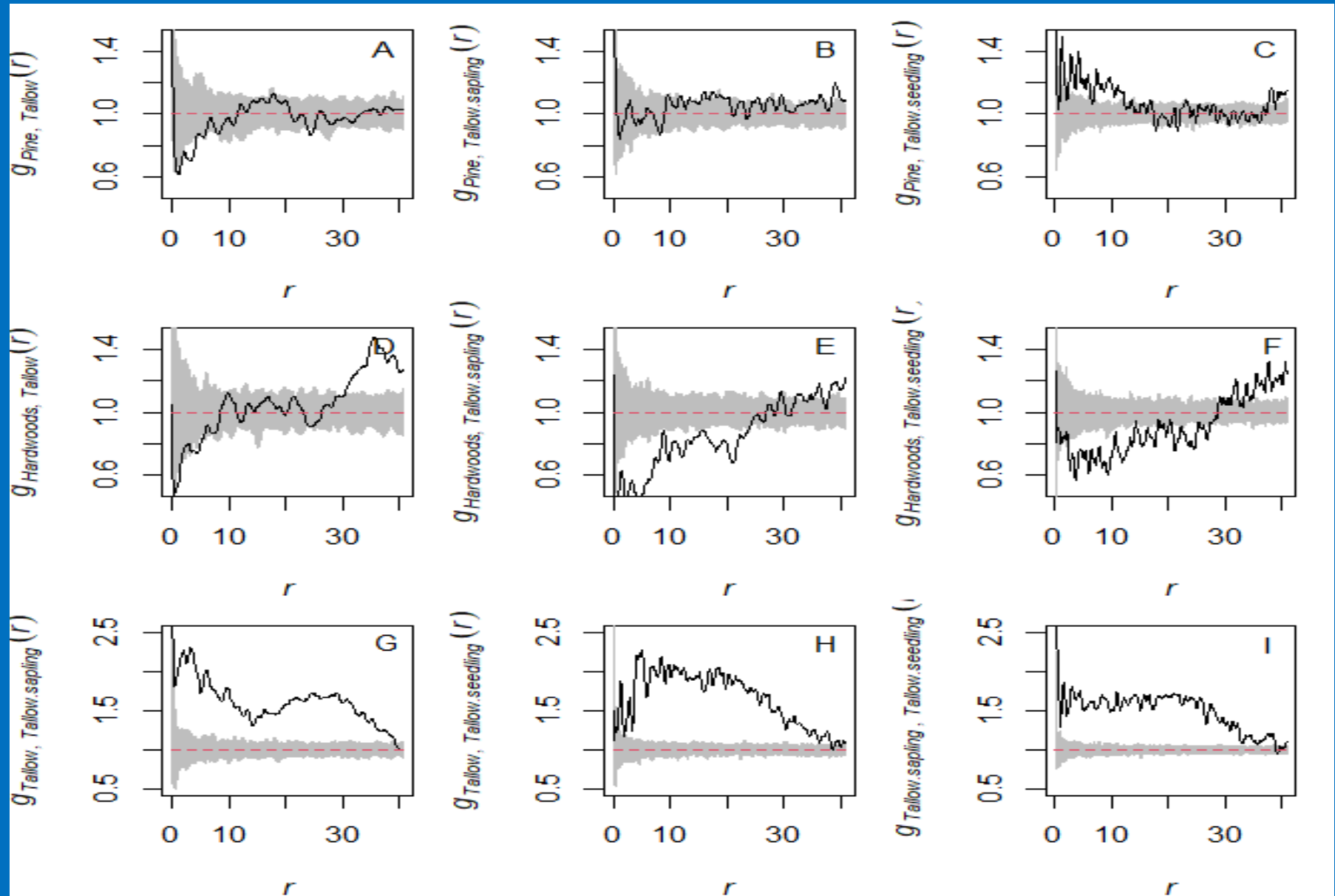
Methods

- First, generate a multitype planar point process (PPP) to $\{Z(s), s \in D\}$ to quantify/map the spatial distribution of Chinese tallow and other native species.
- Compute the cross-type pair correlation function (pcfcross, $g(r)$) to examine the spatial relationship between tallow (seedlings, saplings and trees) and other overstory trees (pine and hardwoods) across different spatial scales r .
- Compute the nonparametric (smoothed) rho-hat ($\rho(Z(s))$) function to quantify the partial effect of individual filters on local intensities of tallow trees, saplings and seedlings.
- Run the multitype point process model (*relrisk.ppm*) by incorporating the polynomials of all six spatial filters to predict spatial probability of tallow:
$$P(y, u) = X \left(\beta + \beta_y \right) + \varepsilon$$

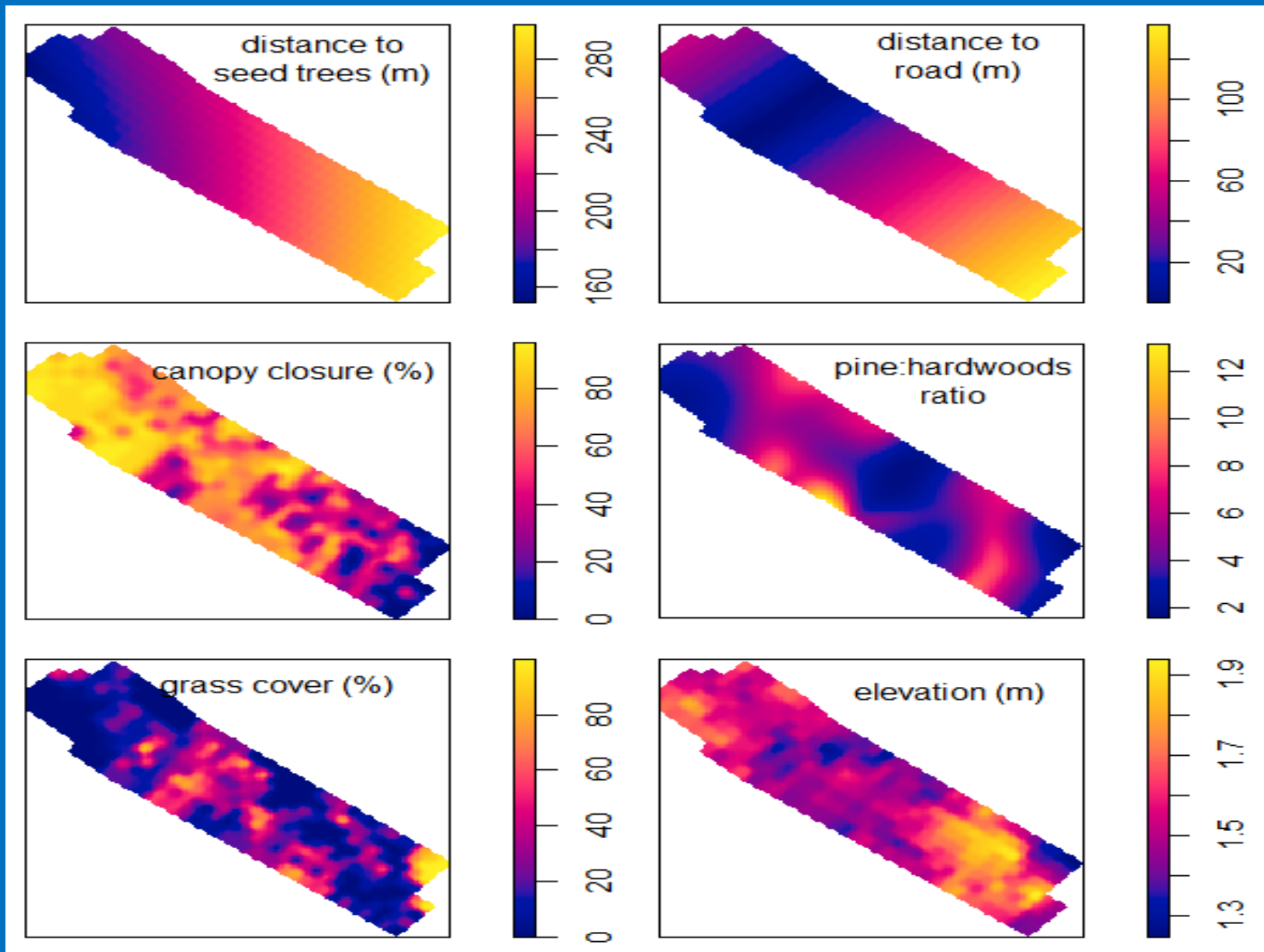
Results: Spatial distribution patterns



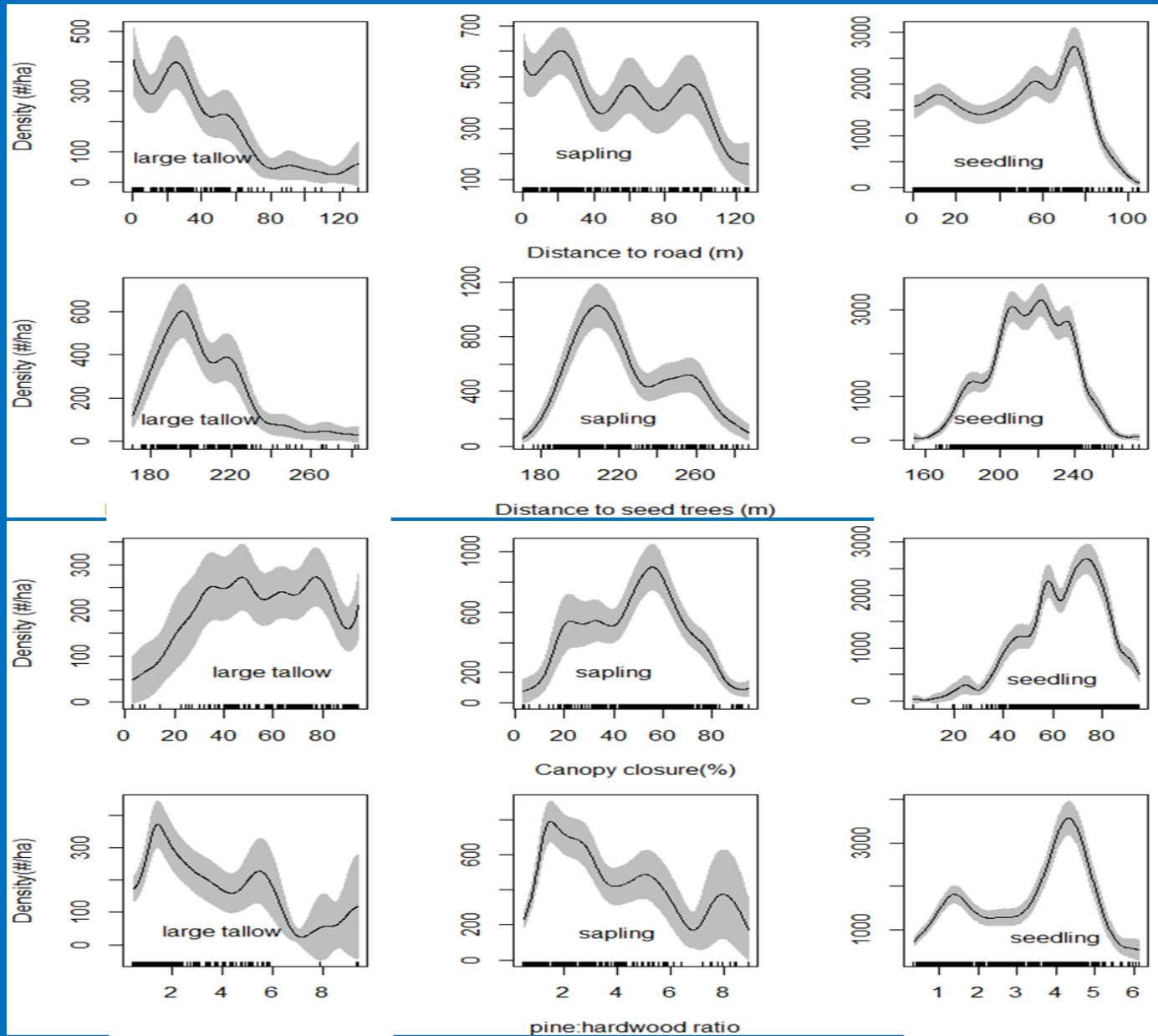
Results: Spatial relationships between tallow and overstory pine and hardwoods



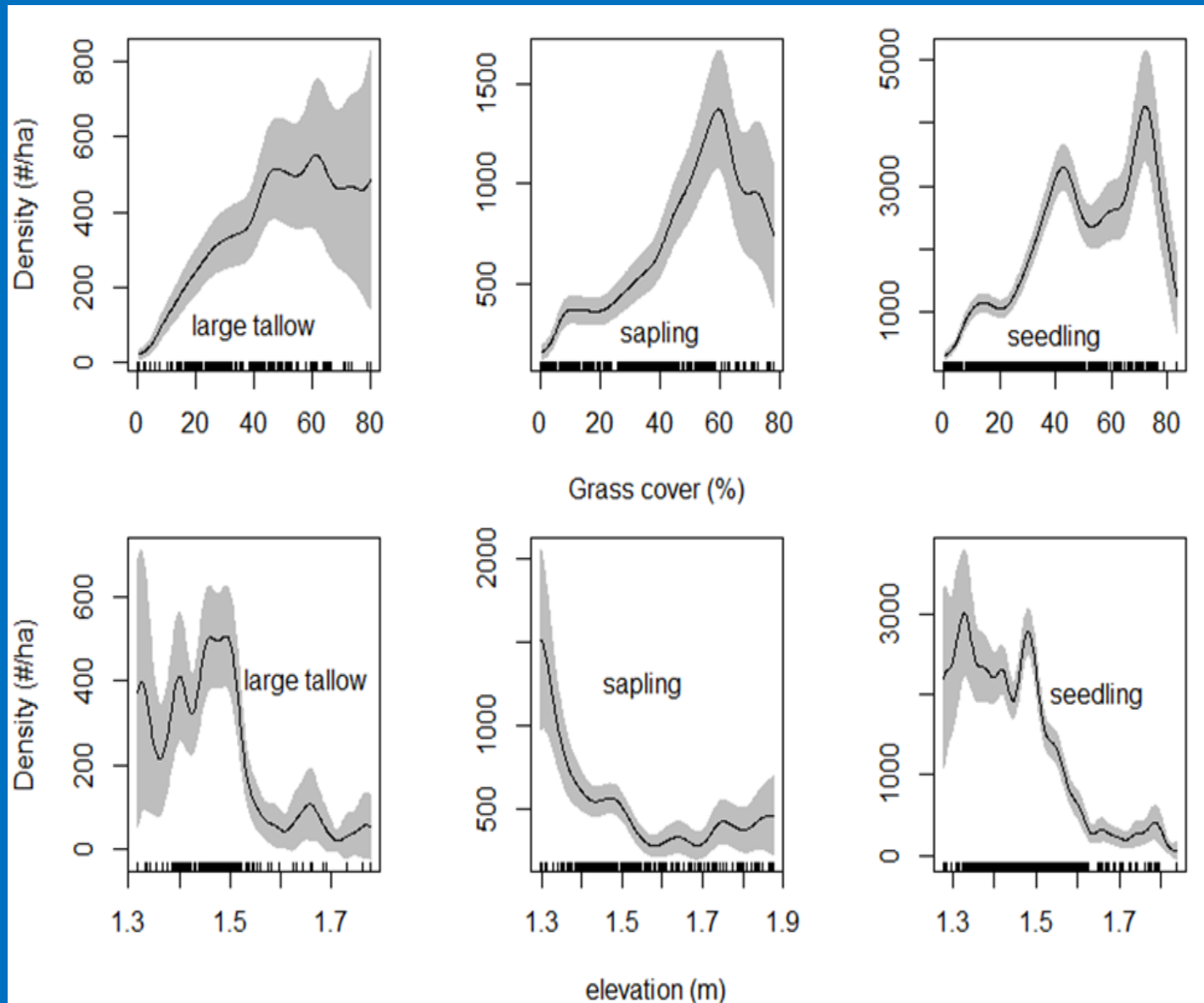
Results: Spatial heterogeneity of biotic and abiotic filters used in this study



Results: Change of local densities of tallow with biotic and abiotic filters

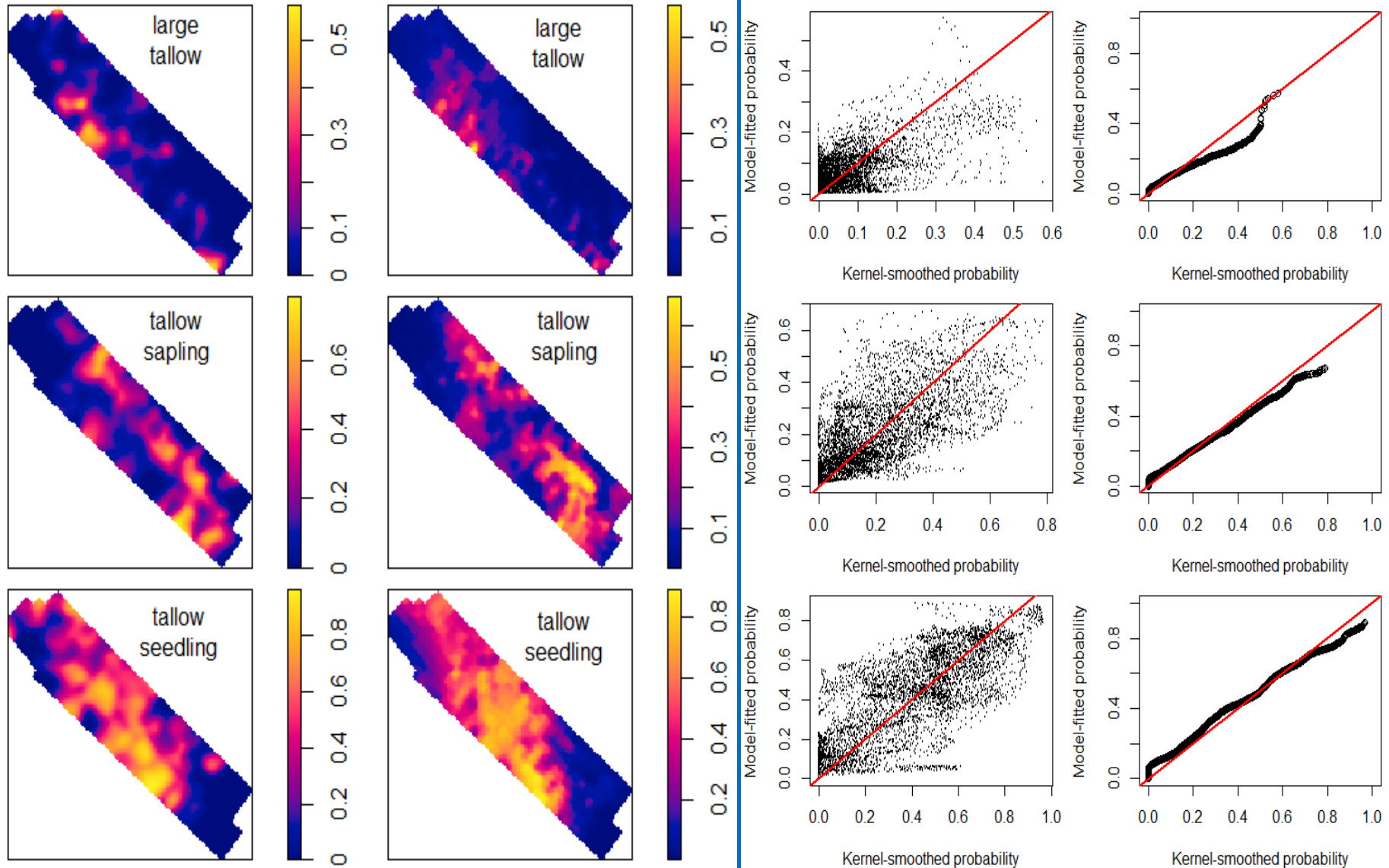


Results : Change of local densities of tallow with biotic and abiotic filters (cont.)



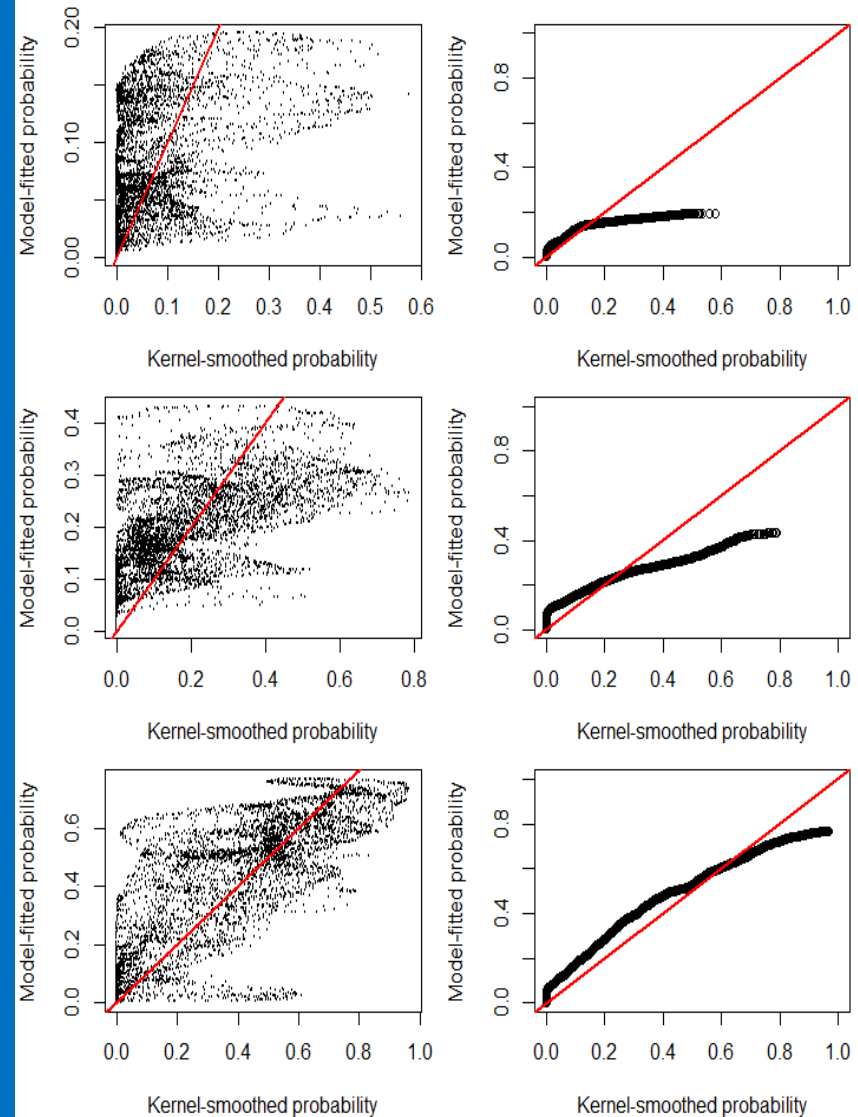
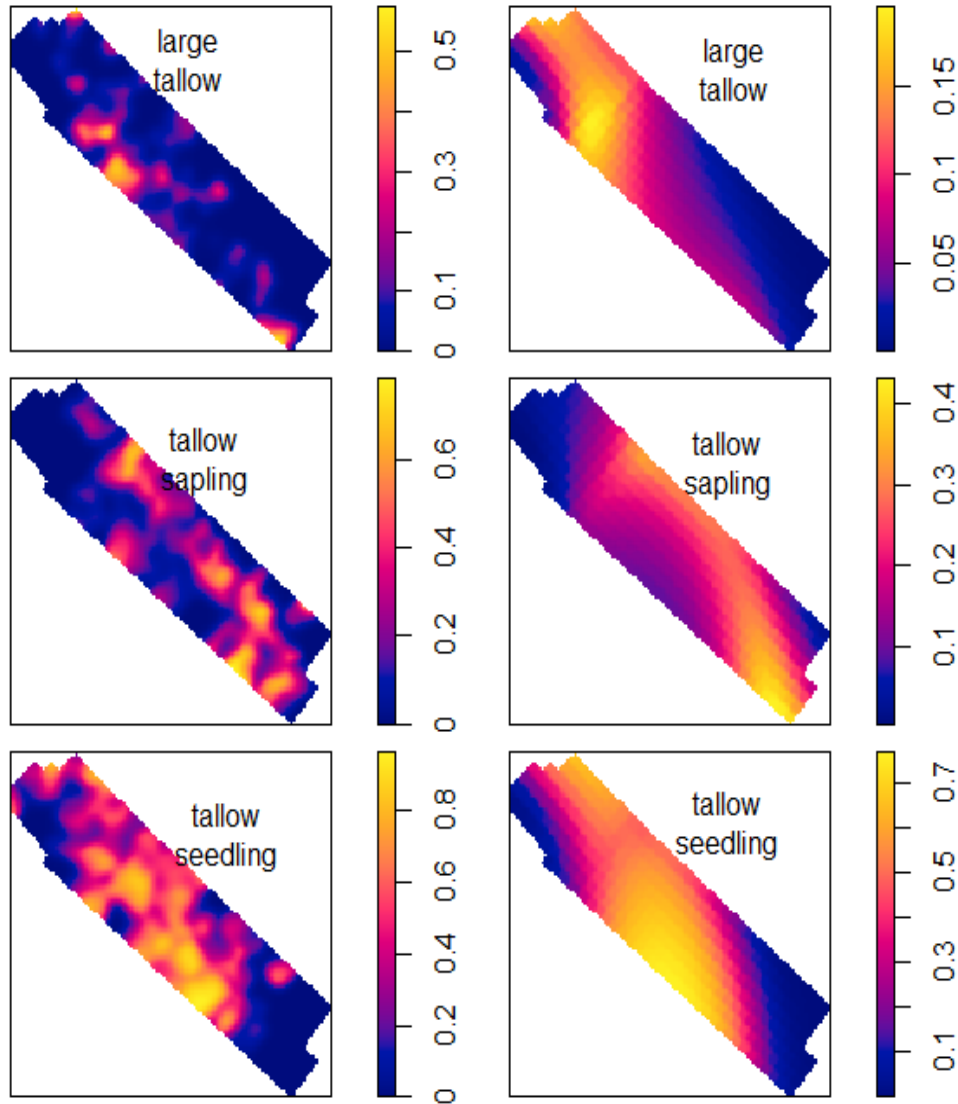
Results: Model performances and diagnostics

Full model: D+O+U



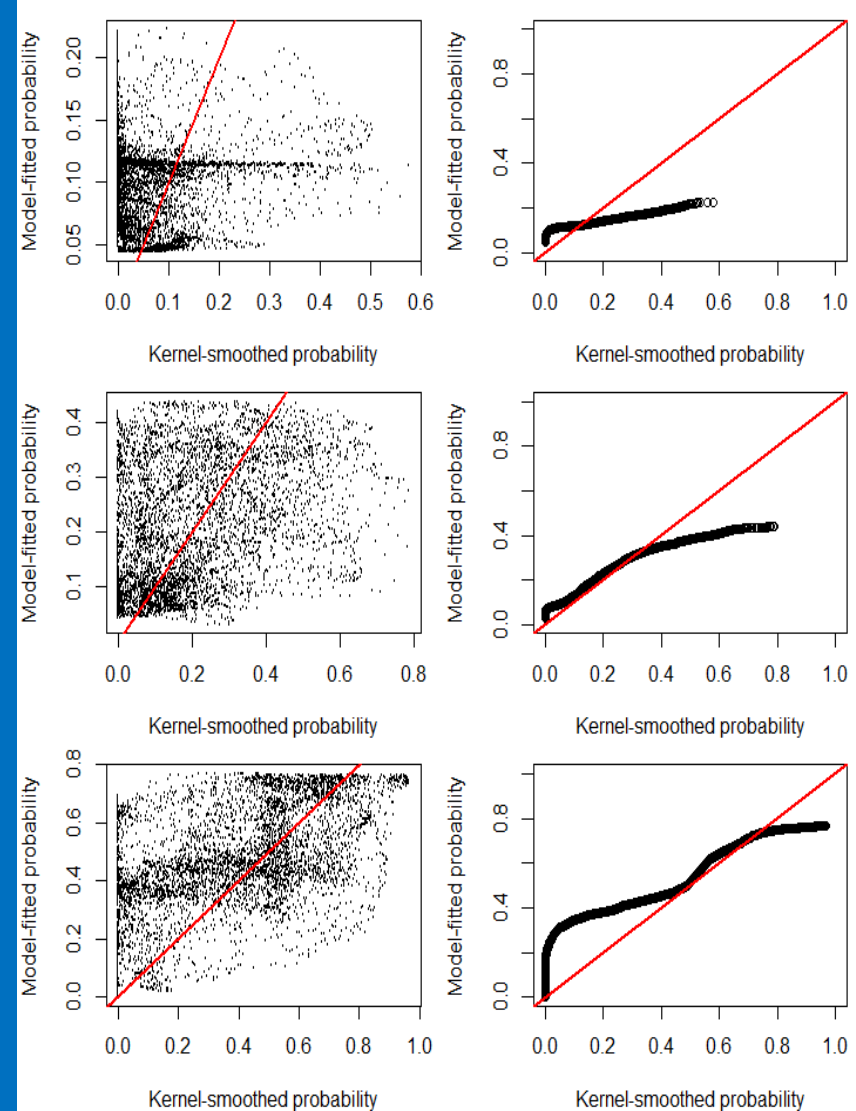
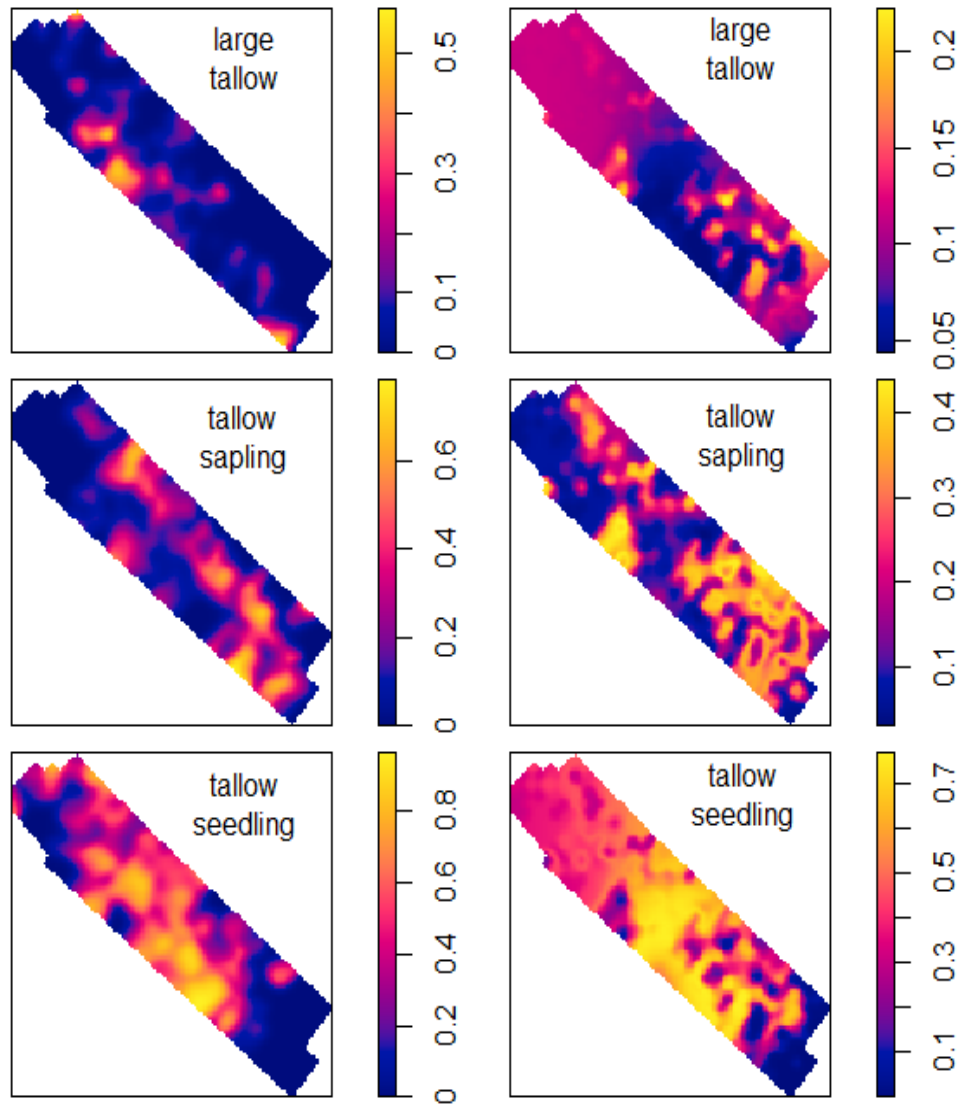
Results: Model performances and diagnostics

The sub-model with dispersal filters



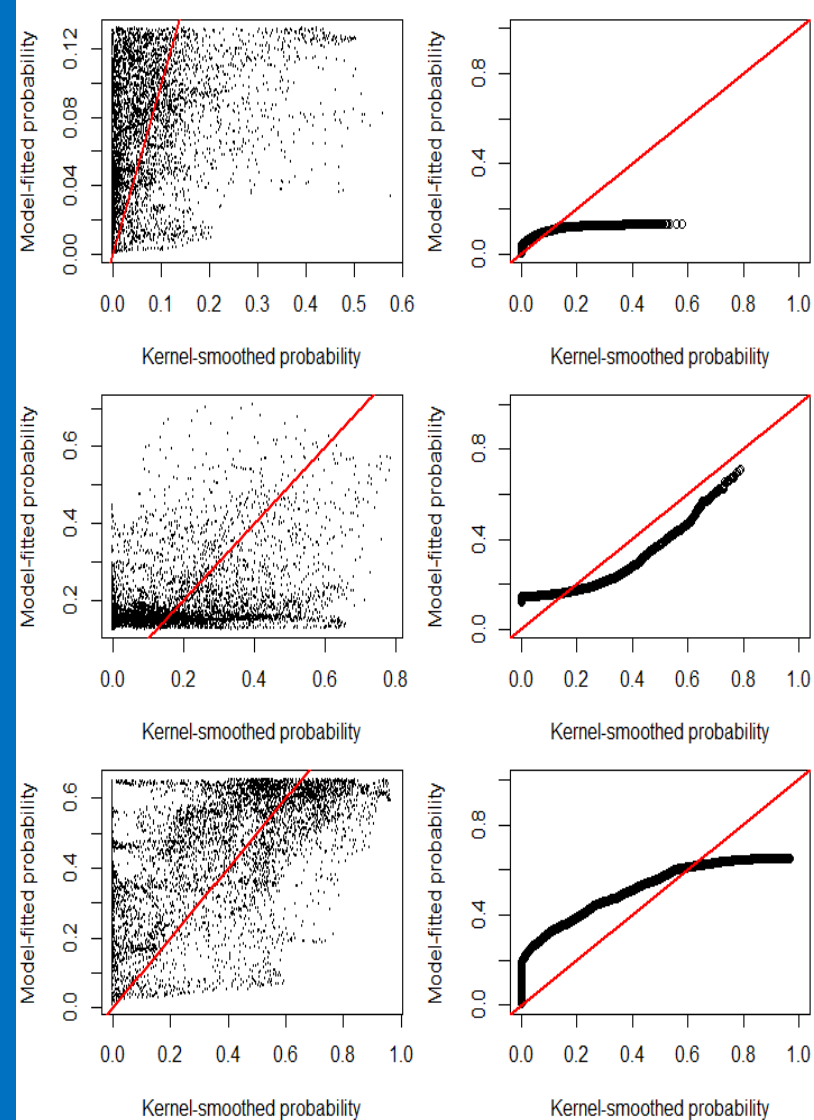
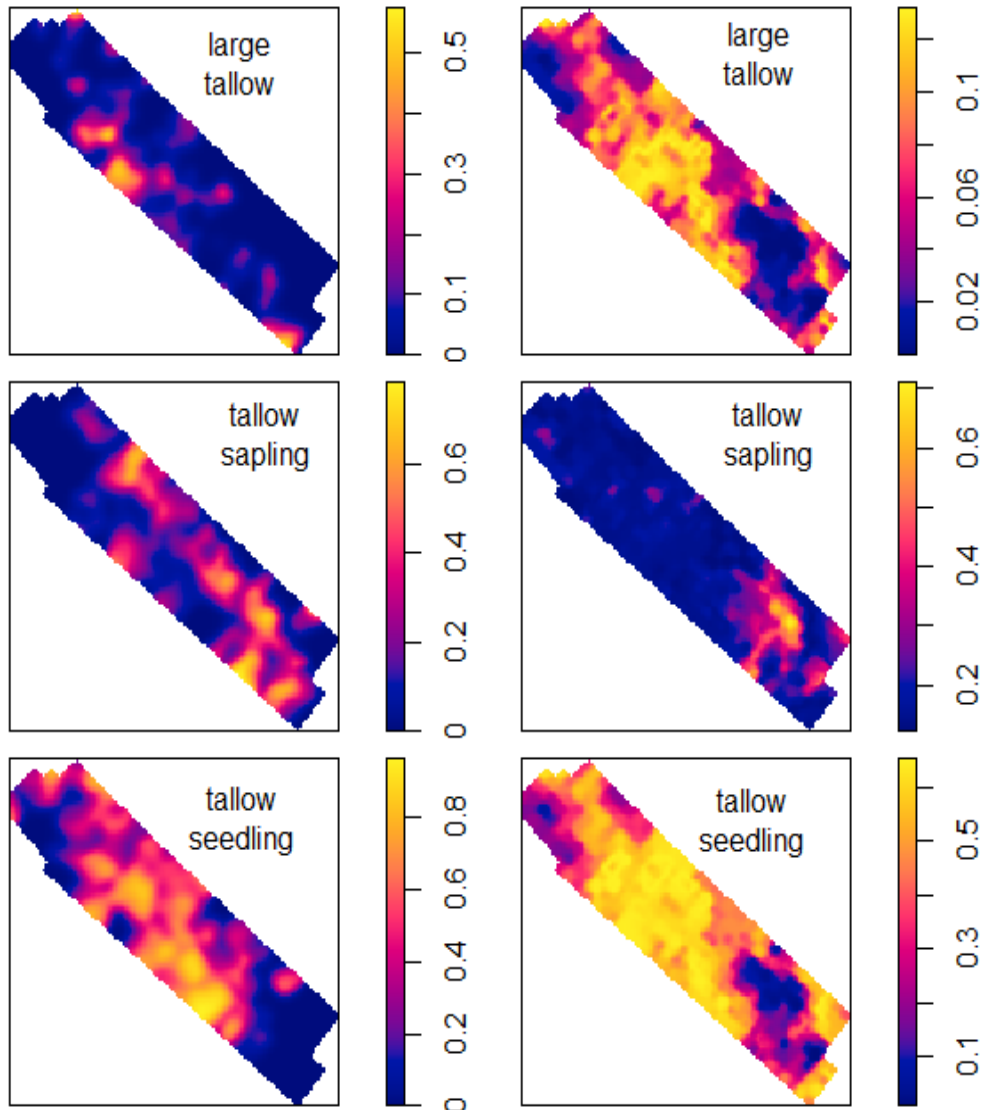
Results: Model performances and diagnostics

The sub-model with overstory filters



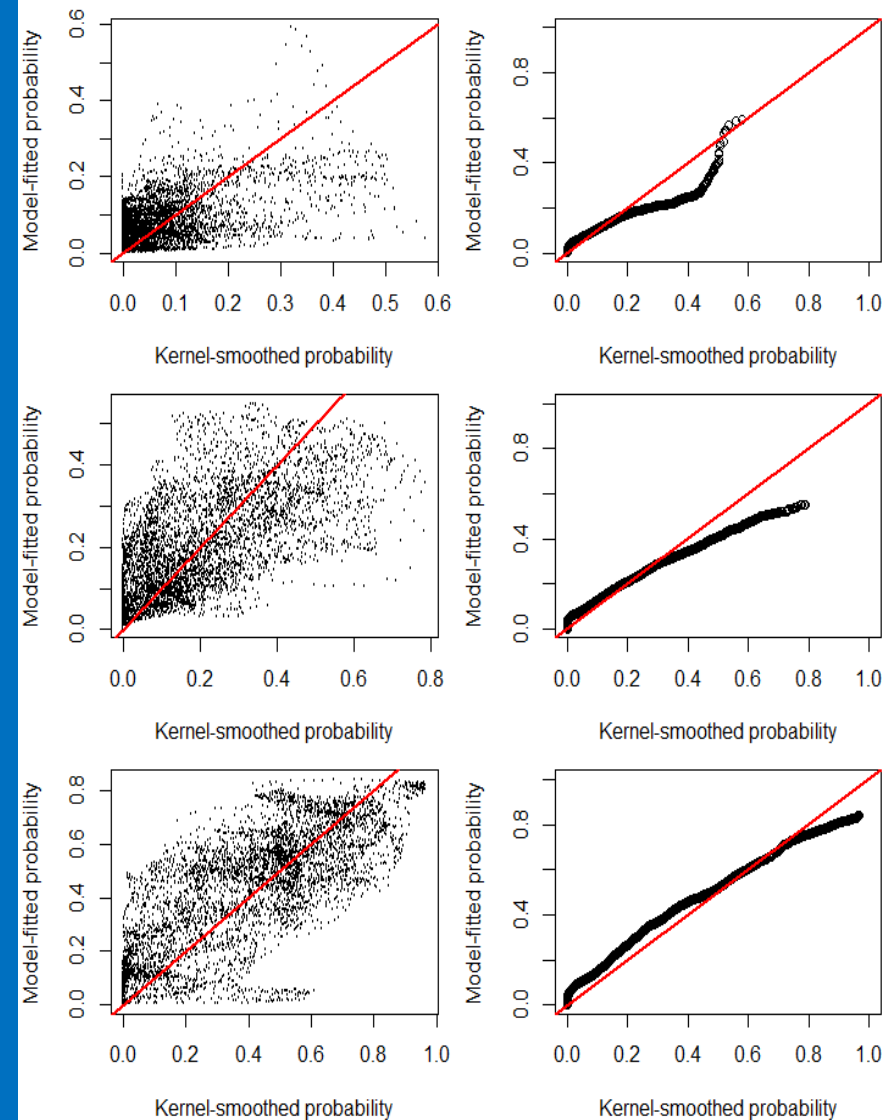
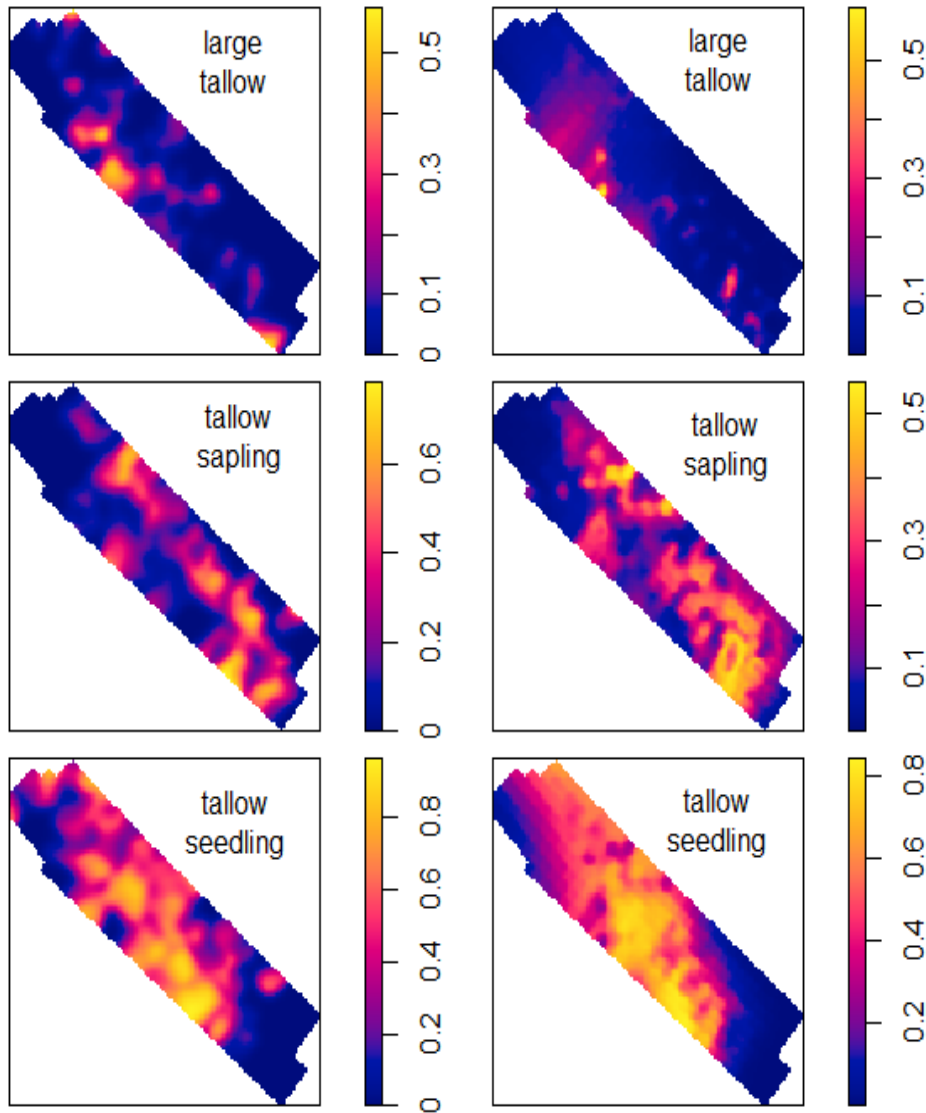
Results: Model performances and diagnostics

The sub-model with understory filters



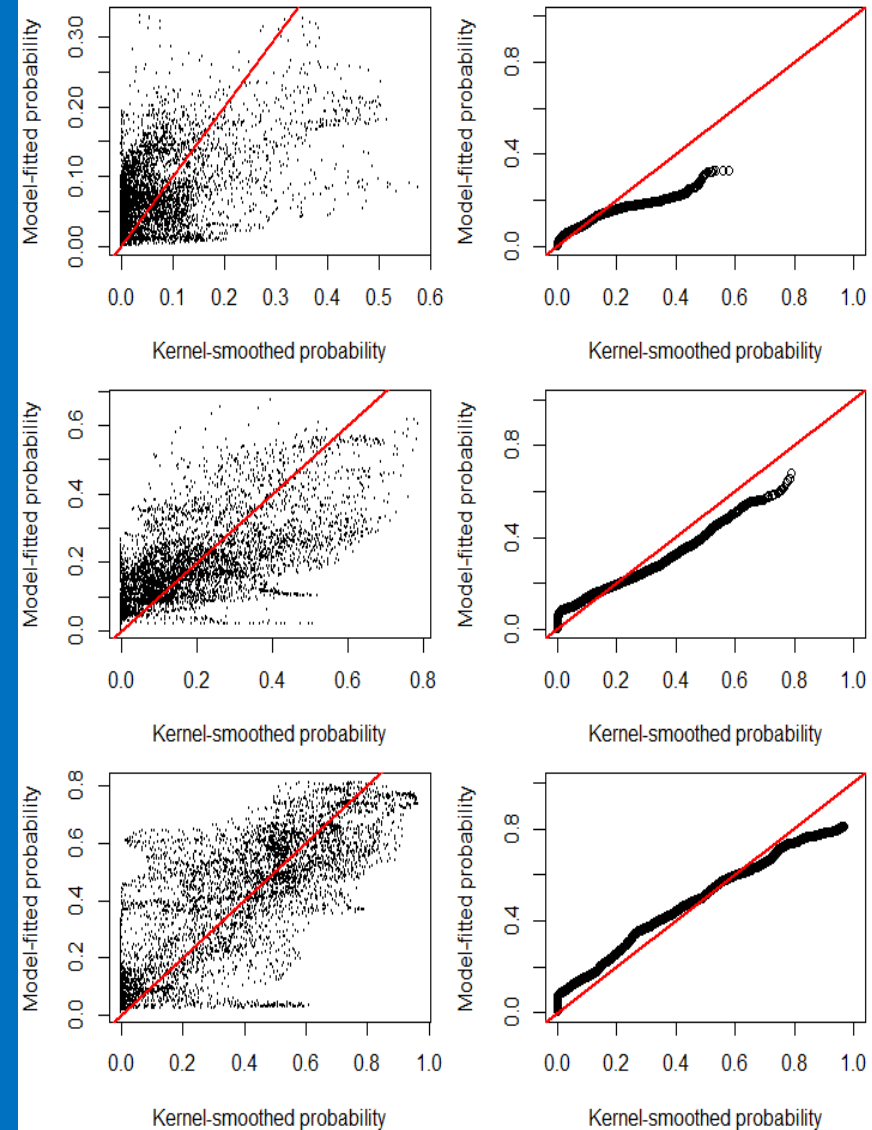
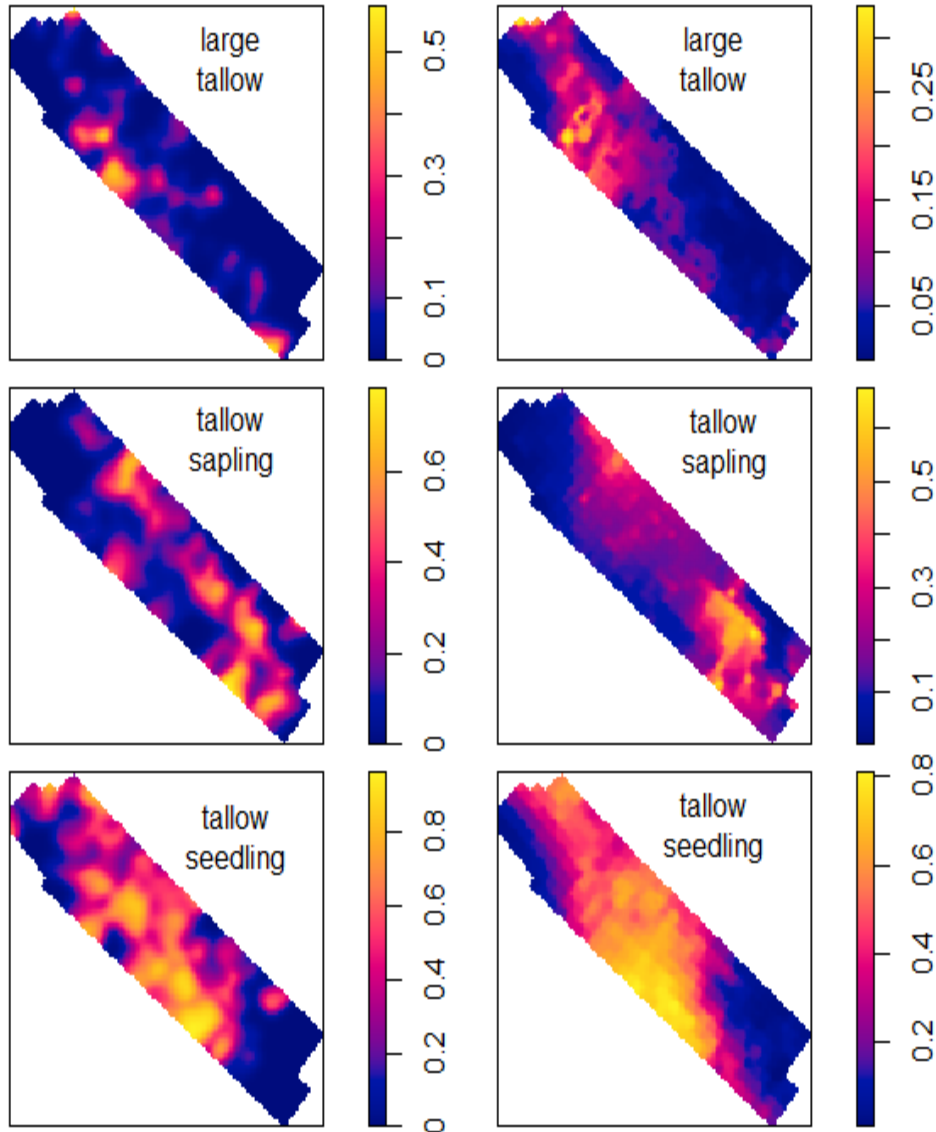
Results: Model performances and diagnostics

The sub-model with dispersal + overstory filters



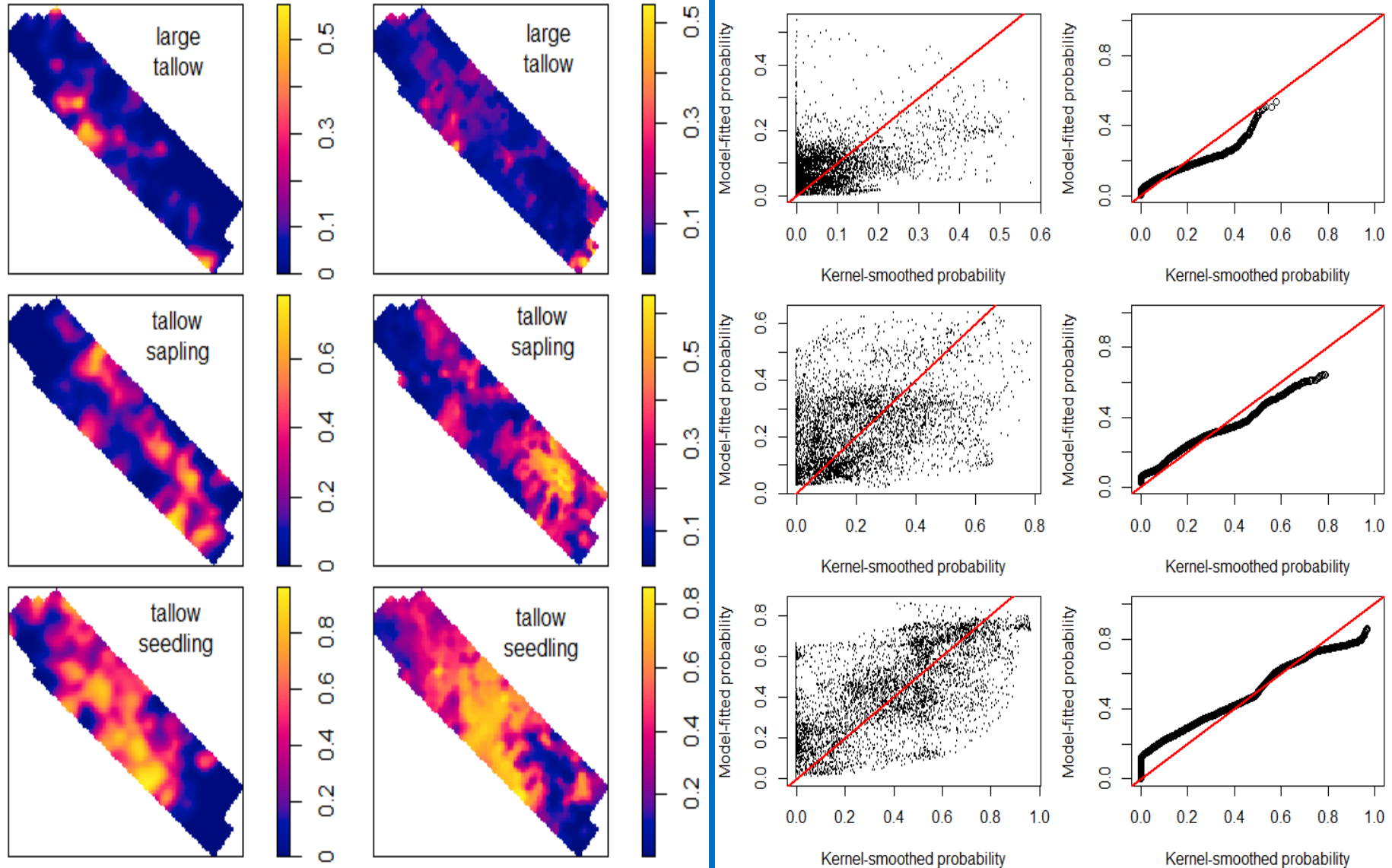
Results: Model performances and diagnostics

The sub-model with dispersal + understory filters



Results: Model performances and diagnostics

The sub-model with overstory + understory filters



Results: Multitype point process models (full models and sub-models)

Size classes	Large tallow trees			Saplings			Seedlings		
Model types	R ²	Skewness	RSE	R ²	Skewness	RSE	R ²	Skewness	RSE
Full model (D + O + U)	0.464	1.611	0.071	0.498	0.467	0.123	0.637	0.262	0.160
Dispersal filters (D)	0.172	2.020	0.088	0.420	0.587	0.133	0.634	0.059	0.161
Overstory filters (O)	0.001	2.137	0.097	0.193	0.843	0.156	0.360	0.006	0.213
Understory filters (U)	0.144	1.946	0.089	0.129	0.813	0.163	0.266	-0.104	0.228
D + O	0.334	1.831	0.079	0.464	0.655	0.128	0.644	0.281	0.159
D + U	0.309	1.669	0.080	0.464	0.654	0.127	0.608	0.015	0.167
O + U	0.192	1.381	0.087	0.236	0.751	0.152	0.473	-0.002	0.193
Full - grass cover	0.384	1.618	0.076	0.508	0.569	0.122	0.635	0.178	0.161
Full - DEM	0.471	1.608	0.070	0.430	0.435	0.131	0.653	0.318	0.157
Full - pine: hardwood ratio	0.445	1.397	0.072	0.508	0.478	0.122	0.629	0.353	0.162
Full - canopy closure	0.334	1.860	0.079	0.463	0.641	0.128	0.619	-0.103	0.165
Full - seed sources	0.269	1.359	0.083	0.333	0.561	0.142	0.462	-0.028	0.196
Full - distance to road	0.405	1.431	0.075	0.389	0.724	0.136	0.578	0.346	0.173

Summary

- 1) Dispersal filters play a pivotal role for predicting spatial probability of tallow invasion.
- 2) None of the dispersal (D), overstory (O) and understory (U) filters are adequate for predicting spatial probability of tallow invasion. Either D+U filters or D+U filters will be needed to accurately predict spatial probability of tallow invasion.
- 3) The O+U filters define the theoretical invasibility of a community, but the D filters have to be included with the O and/or U filters to define the realized invasibility (observed invasion outcomes).
- 4) Management of tallow should first focus on quantifying the D filters and then evaluating the O and U filters for invasion risk control in conserving slash pine flatwoods

Summary (Cont.)

- 3) The role of fire in tallow invasion changes with invasion stages: short burn interval/time since last fire favors tallow seedling colonization and sapling establishment, but long burn interval favors large tallow tree development.
- 4) Overall, ecosystem invasibility can be quantified using multiple measures and by invasion stages, and the effect contributing factors be evaluated in a spatially-explicit context (landscape).

References

Fan, Z., S. Yang, and X. Liu. 2018. Spatiotemporal patterns and mechanisms of Chinese tallowtree (*Triadica sebifera*) spread along edge habitat in a coastal landscape, Mississippi, USA. *Invasive Plant Science and Management* 11:117-126.

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Questions?