

# Surveillance protocols for invasive plants a simulation approach

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# Background

- Consider a newly detected serious weed incursion targeted for containment or eradication
- Surveillance
  - generally 'ad hoc'; intensive survey in the vicinity of the infestation with sporadic efforts at greater distance
  - Expensive and resource limited
- Methods that maximise chance of detection preferred – minimise negative observations

# Background

- Novel approach; simulate incursion spread, concentrate surveillance in areas susceptible to invasion
- May Improve efficiency of ground surveillance and the success of management actions
- Developed a modelling system for invasive plant spread that can be applied to real landscapes in a GIS
- Basis of a surveillance support tool for use by managers of serious weed incursions

# Surveillance support tool

- Written in Python; 25 functions that replicate seed dispersal by wind, water, and roads, and plant establishment and growth
- Integrated with ArcGIS; can be applied directly to spatial information on the incursion
- Can be parameterised by managers of weed incursions for predicting invasion spread and evaluating surveillance strategies



# Simulation study – Identifying surveillance protocols

## ■ Aim

- To identify surveillance protocols for different weed life forms spreading under different dispersal syndromes in real landscapes

## ■ Method

- Select representative landscape in SE QLD with fragmented and continuous habitat mosaics
- Initiate hypothetical incursions in the landscape and simulate weed spread

# Identifying surveillance protocols

- Method continued
  - Implement surveillance methods through the known incursion and evaluate effectiveness
  - Repeat for different weed life forms spreading under different dispersal mechanisms
  - Identify surveillance protocols
- 'Brute force' simulation approach
  - Avoids analytics
  - Computationally intensive

# Identifying surveillance protocols

- Representative landscape
  - Beaudesert Local Government Area
  - Range of landscapes represented; fragmented, continuous, mountainous and lowlands
  - Accurate spatial information available; 25m DEM, Remnant vegetation layers, Road layers



# Identifying surveillance protocols

- Initiating incursions
  - Cells assigned a probability of incursion; higher probability for larger roads and larger streams
  - Single incursion initiated with a random draw from probability of incursion
- Dispersal and life-history parameters generalised from literature

# Dispersal syndromes

	Kernel	$\alpha$	SD on $\alpha$
<b>Wind</b>	Exponential: $\frac{1}{2\pi\alpha^2} \exp\left[-\left(\frac{r}{\alpha}\right)\right]$	100	50
<b>Water</b>	Fat-tailed linear: $\frac{0.5}{2\alpha} \exp\left[-\left(\frac{r}{\alpha}\right)^{1/2}\right]$	500	250
<b>Roads</b>	Fat-tailed linear: $\frac{0.5}{2\alpha} \exp\left[-\left(\frac{r}{\alpha}\right)^{1/2}\right]$	750	250

- Short distance dispersal –  $\alpha$  sampled from Normal distribution
- Long distance dispersal –  $\alpha$  sampled from Lognormal distribution
- 12 combinations of wind, water, road, and LDD versions applied in simulations

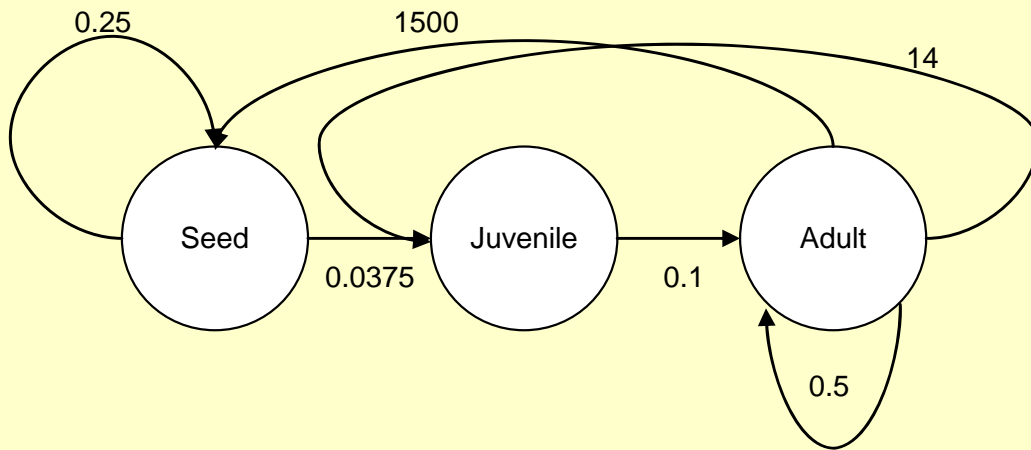
# Life-history parameters

Four stage matrices defined to represent a range of weed life forms

	Annual herbaceous	Perennial herbaceous or woody weed													
High fecundity Short seed longevity	<table border="1"> <tr> <td>0.25</td> <td>1500</td> </tr> <tr> <td>0.00375</td> <td>0</td> </tr> </table> <p>Finite rate of increase=2.5</p>	0.25	1500	0.00375	0	<table border="1"> <tr> <td>0.75</td> <td>0</td> <td>500</td> </tr> <tr> <td>0.015</td> <td>0.25</td> <td>1</td> </tr> <tr> <td>0</td> <td>0.05</td> <td>0.5</td> </tr> </table> <p>Finite rate of increase=1.27</p>	0.75	0	500	0.015	0.25	1	0	0.05	0.5
0.25	1500														
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0	0.05	0.5													
Low fecundity Long seed longevity	<table border="1"> <tr> <td>0.75</td> <td>500</td> </tr> <tr> <td>0.0015</td> <td>0</td> </tr> </table> <p>Finite rate of increase=1.3</p>	0.75	500	0.0015	0	<table border="1"> <tr> <td>0.25</td> <td>0</td> <td>1500</td> </tr> <tr> <td>0.0375</td> <td>0</td> <td>14</td> </tr> <tr> <td>0</td> <td>0.1</td> <td>0.5</td> </tr> </table> <p>Finite rate of increase=2.30</p>	0.25	0	1500	0.0375	0	14	0	0.1	0.5
0.75	500														
0.0015	0														
0.25	0	1500													
0.0375	0	14													
0	0.1	0.5													

# Life-history parameters

■ Example for a perennial weed with high fecundity and short seed longevity



0.25	0	1500
0.0375	0	14
0	0.1	0.5

Finite rate of increase = 2.11

# Example simulations – high fecundity perennial

## ■ Continuous landscape mosaic

- Dispersal by wind 
- Dispersal by wind, water and road 

## ■ Fragmented landscape mosaic

- Dispersal by wind 
- Dispersal by wind, water and road 

# Surveillance methods

## ■ Methodology

- 8 surveillance methods applied annually during simulations
- Surveillance restricted to areas within 2km of initial incursion
- Annually 2% of area was surveyed; 25 hectares within 2km of incursion
- Perfect weed detection rates are assumed

# Surveillance methods

## ■ Methodology

- Cells with detected incursions are stored year to year
- Surveillance methods evaluated using the proportion of detected population
- Equal survey effort was assumed among methods

# Basic surveillance methods

## ■ Basic surveillance

- Random
- Systematic

## ■ Adaptive surveillance

- Targets cells within 500m of detected incursions in next year
- Random adaptive
- Systematic adaptive

# Targeted surveillance methods

- Seek and destroy
  - uses information on dispersal vectors to target susceptible cells
  - Seek and destroy adaptive
- Habitat surveillance
  - uses information on suitable habitat to target susceptible cells
  - Habitat adaptive

# Simulations

100 replicates

Simulated for 10 years  
Surveillance evaluated annually

96 Parameter combinations

12 dispersal syndromes

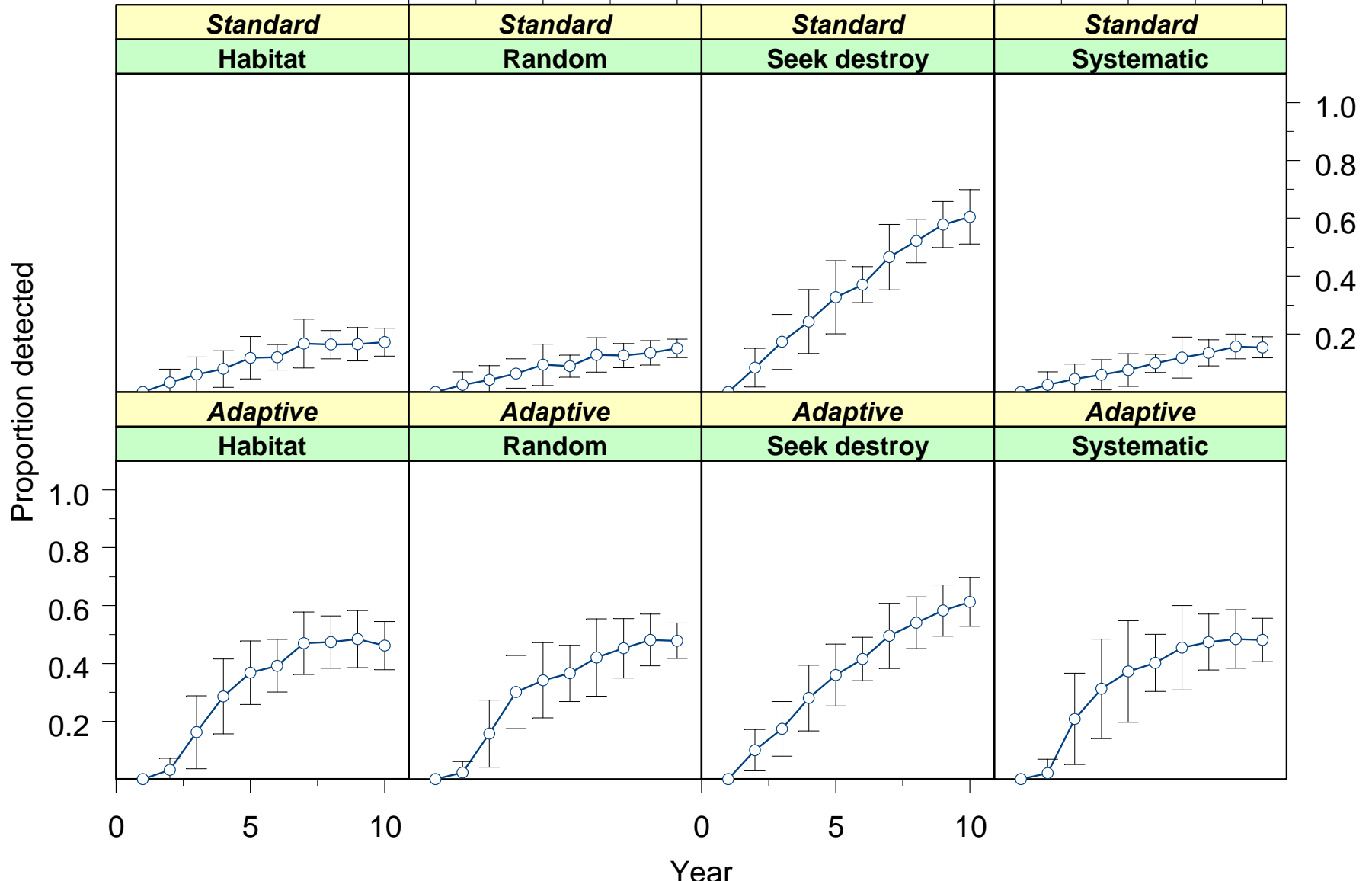
4 life-histories

2 landscape types

# Temporal trends in surveillance efficiency - Continuous landscape

High fecundity annual subject to Wind SDD

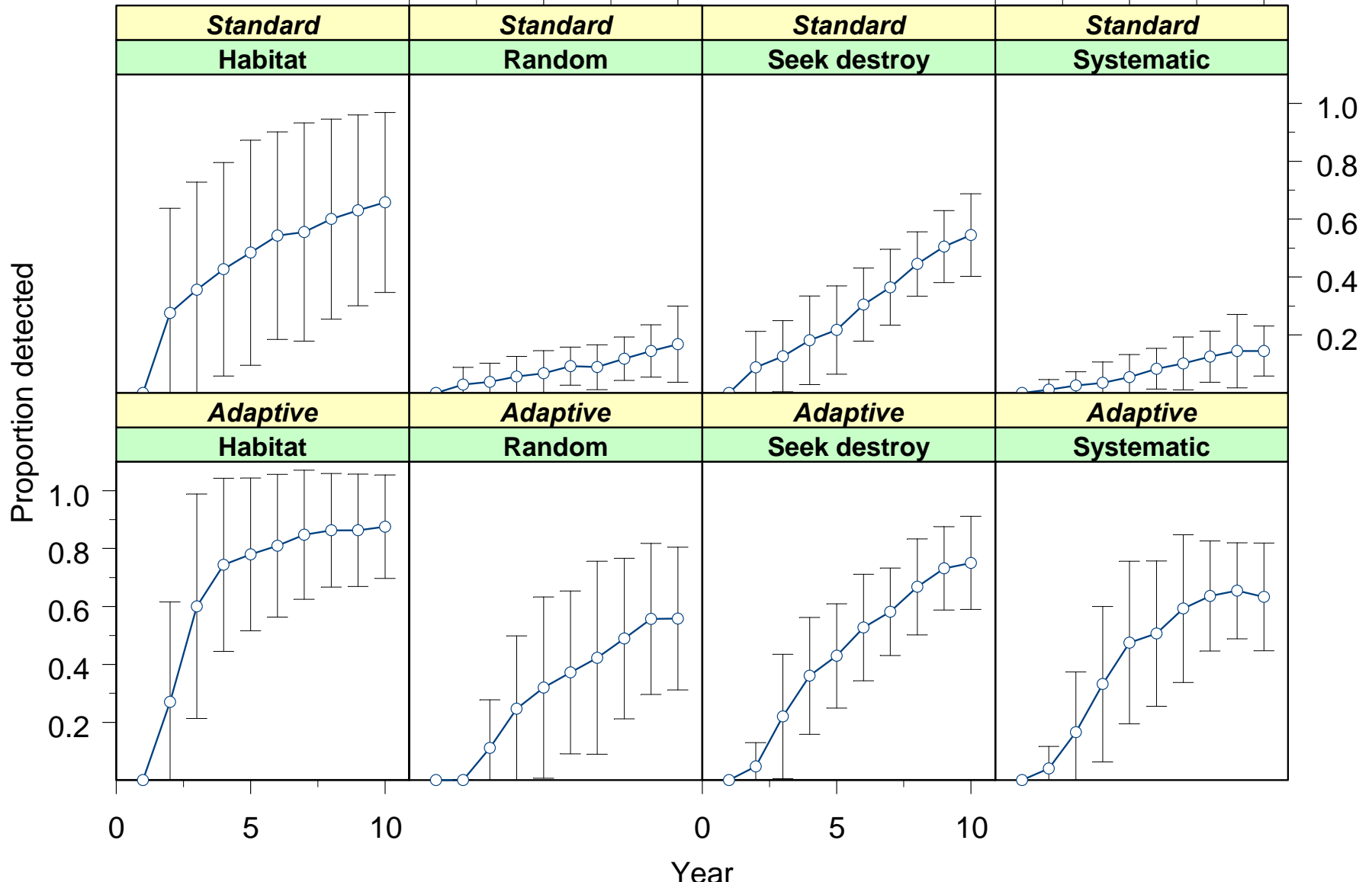
0 5 10 0 5 10



# Temporal trends in surveillance efficiency - Fragmented lanscape

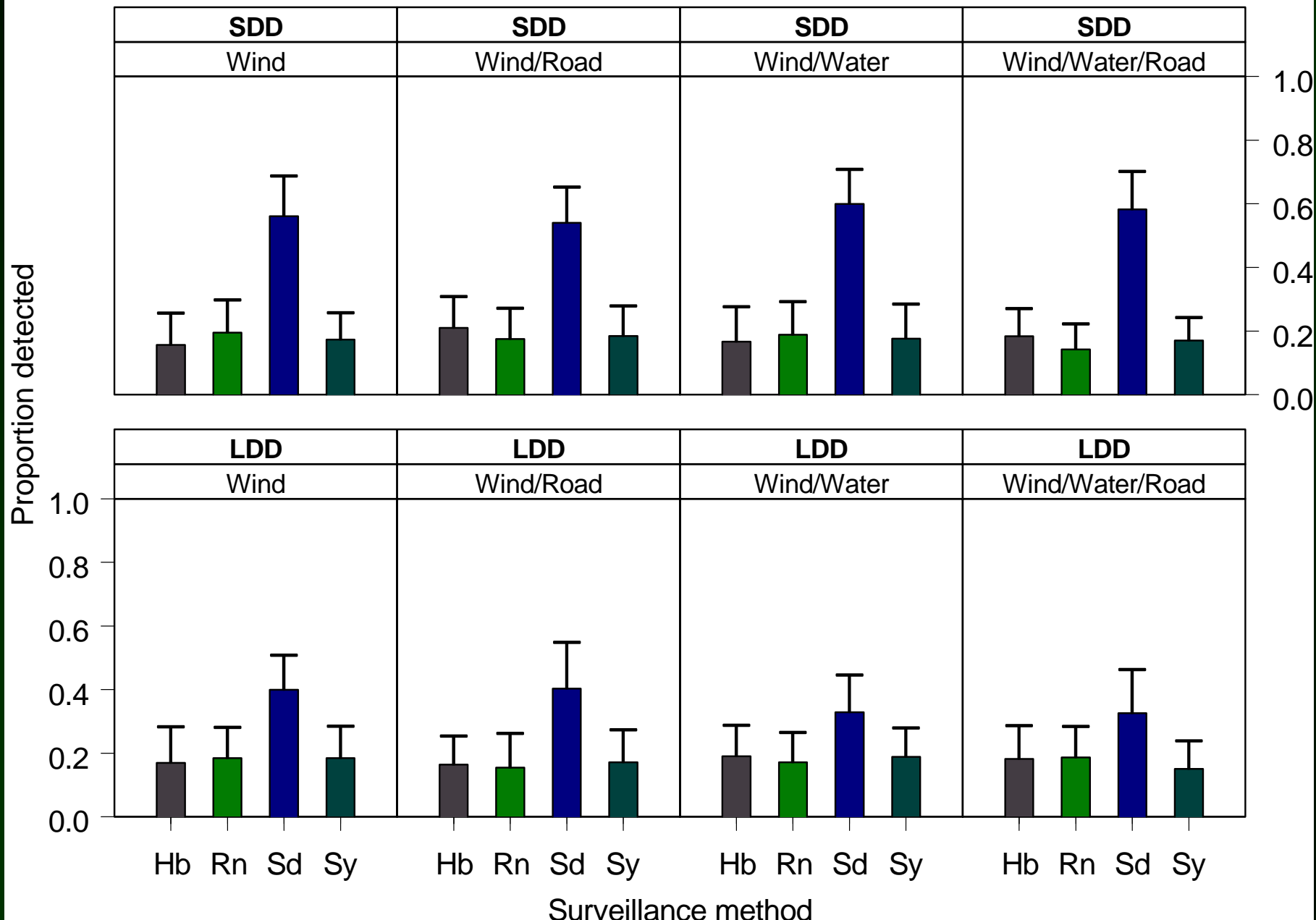
High fecundity annual subject to Wind SDD

0 5 10 0 5 10



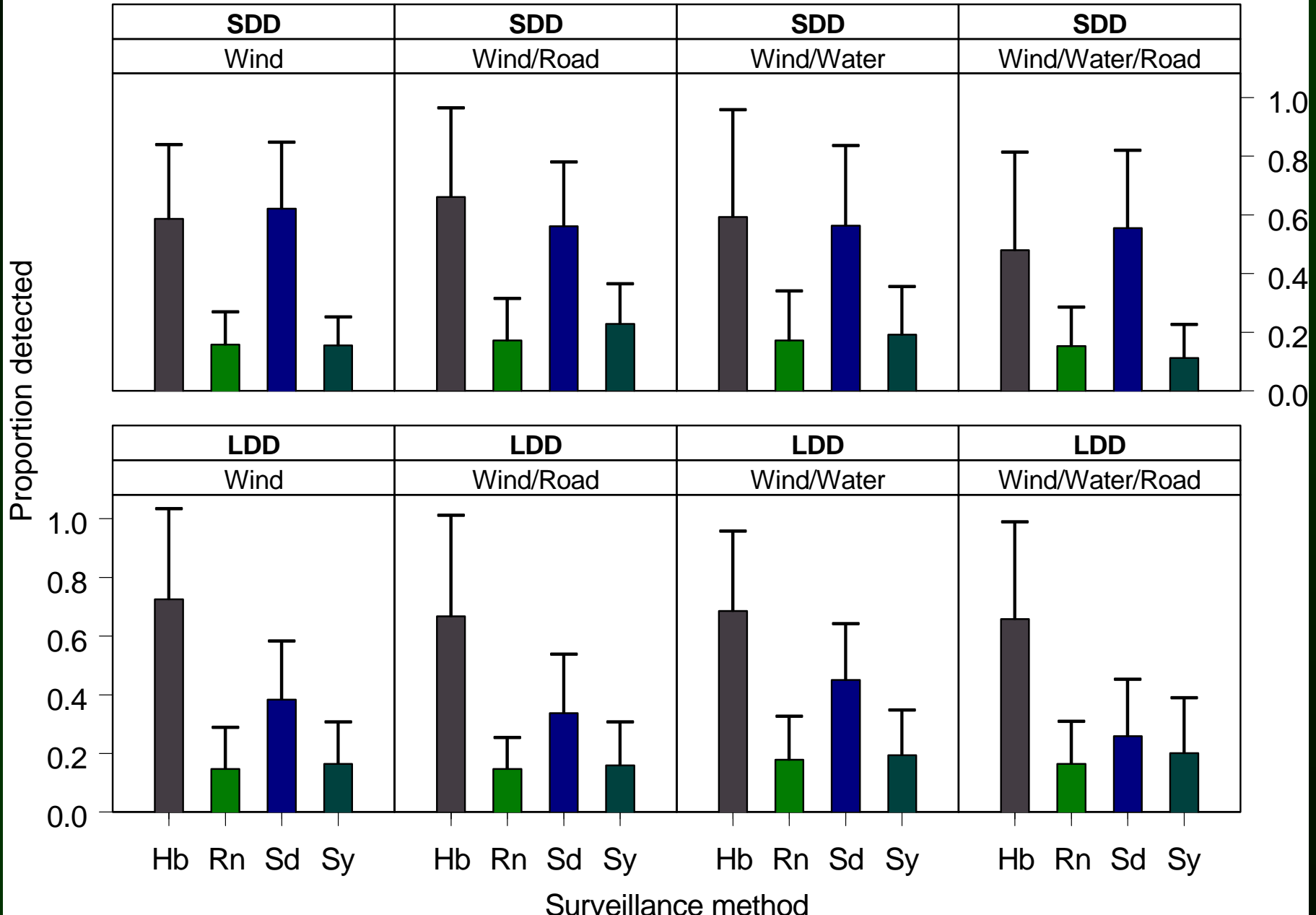
# Standard surveillance in a continuous habitat

Low fecundity perennial



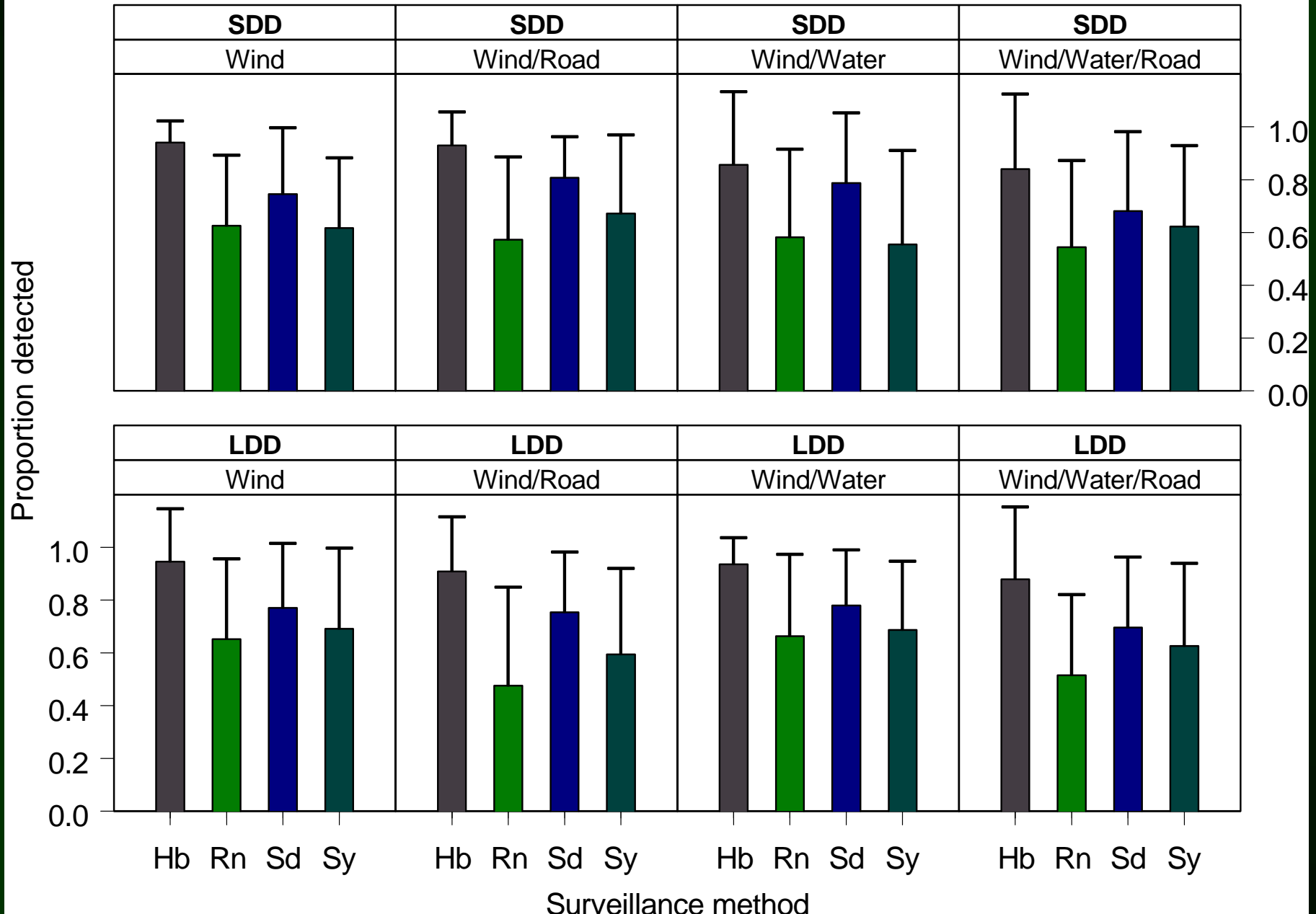
# Standard surveillance in a fragmented habitat

Low fecundity perennial



# Adaptive surveillance in a fragmented habitat

Low fecundity perennial



# Surveillance protocols

- Fragmented habitat mosaic
  - Surveillance in suitable habitat is most effective
- New incursions in a fragmented mosaic
  - Identify habitat preferences
  - Target suitable habitat in surveillance



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# Surveillance protocols

- Continuous habitat mosaic
  - Surveillance based on 'seek and destroy' method most effective
- New incursions in a continuous habitat mosaic
  - Identify dispersal vectors
  - Target areas vulnerable to dispersal vectors using 'seek and destroy'



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# Surveillance protocols

- Adaptive surveillance is always superior, and should be used
- Systematic and random methods are inferior
- Should use information on habitat preferences or dispersal vectors to target surveillance
- 'Ad hoc' surveillance can be improved by targeting areas susceptible to invasion



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# Surveillance protocols

- Simulations were very different across dispersal syndromes, growth forms and life histories – not reflected in terms of surveillance efficiency
- First cut – will run for longer time periods – subtle differences may become more pronounced



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# Surveillance protocols

- Mechanistic elements can be refined
- More surveillance methods
- Results bound by assumptions of the simulation
- Summary
  - ‘Ad hoc’ surveillance can be improved by targeting areas susceptible to invasion



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