Bridal creeper invasion alters nutrient cycling and increases available soil nutrients

Pete Turner, John Scott & Helen Spafford
1. Background to Australia
   - bridal creeper
   - soil nutrients

2. Mechanisms for the increase in the availability of nutrients following bridal creeper invasion

3. Implications following management
Bridal creeper and soil nutrients in southern Australia
Asparagus asparagoides: native to southern Africa

South Africa
(Kleinjan & Edwards 1999)

Australia
(Morin et al. 2006)
Bridal creeper

- is a geophyte from southern Africa
- first records in Australia date back to 1870s
- invades disturbed and undisturbed habitats in native bushland
- now widespread throughout southern Australia
Changes to soil nutrients is important in Australian context

For example across southern Australia:

- Native species richness negatively correlated to soil nutrients
- Non-native species richness positively correlated to soil nutrients

Photo: John Virtue
Changes to soil nutrients is important in Australian context

For example across southern Australia:

- Native species richness negatively correlated to soil nutrients
- Non-native species richness positively correlated to soil nutrients
- Experimentally, increases in nutrients have:
  - increased survival rates of non-natives
  - increased mortality of native plants
  - resulted in a hastened life cycle and an early death of natives
  - a decrease in native species tolerance to drought
Asparagus asparagoides:
in southern Western Australia (W.A.)

South Africa
(Kleinjan & Edwards 1999)

Australia
(Morin et al. 2006)

Glenlynn Conservation Reserve

Fitzgerald River National Park
Example of sites

Reference areas

Bridal creeper areas
Soils in southern W.A. are protected from invasion

Ancient, highly weathered, nutrient poor soils with only small amounts of phosphorus available to plants

High phosphate adsorption in acidic soils leading to plant roots and the soil surface competing for the supply of available phosphorus

Many native species re-absorb phosphorus before litterfall, keeping nutrient pool low
Soil nutrients are higher where bridal creeper grows.

Available phosphorus (mg/kg)

Ammonium (mg/kg)

**Bridal creeper RGR (mg/g/day)**

- **Reference soil**
  - No competition
  - With Thomasia
  - With Billardiera
  - With Veldt grass

- **Bridal creeper soil**
  - No competition
  - With Thomasia
  - With Billardiera
  - With Veldt grass
Bridal creeper increases soil nutrients in southern Western Australia
Bridal creeper can increase soil nutrients

1. Change in plant functional type
2. Higher nutrient levels in foliage
3. Shorter lifespan of foliage with aboveground growth senescing every year
4. Rapid decomposition of nutrient rich litter
5. Root architecture
Nutrient cycling of bridal creeper

Foliage chemistry

Litterfall

Nutrient pools

Decomposition

Tuberous roots
Eight year removal experiment in South Australia (Turner & Virtue 2006)
Shift in nutrient pools from biomass to soil

Percent cover of native trees and shrubs (<1.5m)

- **Glenlynn Conservation**
- **Gairdner River**
- **Quell Creek**
- **Quaalup Homestead**

The graph shows the percent cover of native trees and shrubs in different areas, comparing Bridal creeper area to Reference area.
Nutrient cycling of bridal creeper

Foliage chemistry → Litterfall → Decomposition → Tuberous roots → Nutrient pool shift
Bridal creeper foliage from southern Western Australia

<table>
<thead>
<tr>
<th></th>
<th>Bridal creeper</th>
<th>Native species*</th>
<th>Introduced species*</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (mg/g)</td>
<td>24.2 ± 1.5</td>
<td>9.7</td>
<td>13.2</td>
</tr>
<tr>
<td>P</td>
<td>1.7 ± 0.2</td>
<td>0.7</td>
<td>1.7</td>
</tr>
</tbody>
</table>

* Foulds (1993) from 696 collections from SW Australia
Nutrient cycling of bridal creeper

Nutrient rich foliage → Litterfall → Decomposition → Tuberous roots → Nutrient pool shift
• Increase in the amount of litterfall in bridal creeper areas when the weed senesces

• Phosphorus retained in the litterfall

<table>
<thead>
<tr>
<th></th>
<th>Green bridal creeper foliage (June)</th>
<th>Senesced bridal creeper foliage (Nov/Dec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N mg/g</td>
<td>24.2 ± 1.5</td>
<td>13.6 ± 0.6</td>
</tr>
<tr>
<td>P</td>
<td>1.7 ± 0.2</td>
<td>1.2 ± 0.3</td>
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</tbody>
</table>
Nutrient concentration for litter trapped Oct-Dec 2005

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Bridal creeper areas</th>
<th>Reference areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (mg/g)</td>
<td>16.1 ± 0.8</td>
<td>7.2 ± 0.4</td>
</tr>
<tr>
<td>Phosphorus (mg/g)</td>
<td>1.4 ± 0.2</td>
<td>0.3 ± 0.1</td>
</tr>
</tbody>
</table>
Nutrient cycling

Increased nutrient rich litterfall

Nutrient rich foliage

Nutrient pool shift

Decomposition

Tuberous roots
Decomposition

**Bridal creeper**

- Biomass
- Nitrogen
- Phosphorus

**Eucalyptus spp.**

- Nitrogen
- Biomass
- Phosphorus
Decomposition

After 12 months:

- Bridal creeper (Eucalyptus spp.)
- Percent remaining: 0% for Biomass, 20% for Nitrogen, 40% for Phosphorus

- Eucalyptus spp.
- Percent remaining: 60% for Biomass, 40% for Nitrogen, 20% for Phosphorus
Nutrient cycling

Nutrient rich foliage → Increased nutrient rich litterfall

Nutrient pool shift → Rapid decomposition and leaching of nutrients

Tuberous roots
Nutrient element concentrations of belowground root system of bridal creeper

<table>
<thead>
<tr>
<th></th>
<th>Actively growing plants (June)</th>
<th>Senesced plants (Nov/Dec)</th>
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</thead>
<tbody>
<tr>
<td><strong>N mg/g</strong></td>
<td>14.78 ± 0.88</td>
<td>9.30 ± 1.35</td>
</tr>
<tr>
<td><strong>P</strong></td>
<td>0.81 ± 0.07</td>
<td>0.48 ± 0.07</td>
</tr>
</tbody>
</table>
Tuberous root mats can minimise nutrient losses by scavenging nutrients directly from decomposing litter.

**Root biomass** (dry weight kg/m²)

<table>
<thead>
<tr>
<th>Site name</th>
<th>Biomass (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quell Creek</td>
<td>3.0</td>
</tr>
<tr>
<td>Quaalup Homestead</td>
<td>3.7</td>
</tr>
<tr>
<td>Gairdner River</td>
<td>4.9</td>
</tr>
<tr>
<td>Glenlynn Conservation</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Tuberous root mats can minimise nutrient losses by scavenging nutrients directly from decomposing litter and trap nutrients that enter the system from elsewhere.
Increased rate of nutrient cycling

- Nutrient rich foliage
- Increased nutrient rich litterfall
- Nutrient pool shift
- Rapid decomposition and leaching of nutrients
- Tuberous roots trap nutrients
Bridal creeper roots impacted native bluebell creeper

Billardiera fusiformis (root:shoot ratio)

Dead root material  Live root material  Control
Allelopathy???

Control

Dead root solution

Live root solution
Implications for recovery of invaded sites in southern Western Australia
Bridal creeper cover has reduced following biological control
Many other alien plant species can be found in the soil below bridal creeper that will readily germinate.

**Abundance m²**

- **Exotic species**
- **Native and unidentified species**

<table>
<thead>
<tr>
<th>Location</th>
<th>Seeds m²</th>
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<tbody>
<tr>
<td>GR</td>
<td></td>
</tr>
<tr>
<td>QH</td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td></td>
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</tbody>
</table>
The residual impact of the invader will remain after control

- Exotic species richness positively correlated to soil nutrients

- *Ehrharta longiflora* – RGR (mg/g/day)

- Elevated phosphorus levels can remain in the system for many years
The residual impact of the invader will remain after control

- Additional management of sites will be needed as soils will no longer be protected from invasion of other species
Soils in SW Australia invaded by bridal creeper have elevated nutrient levels
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Bridal creeper has increased the rate of nutrient cycling
Soils in SW Australia invaded by bridal creeper have elevated nutrient levels

Bridal creeper has increased the rate of nutrient cycling

Gradual shift of nutrient pools from biomass to the soil
Soils in SW Australia invaded by bridal creeper have elevated nutrient levels.

Bridal creeper has increased the rate of nutrient cycling.

Gradual shift of nutrient pools from biomass to the soil.

Increased nutrient levels will have to be taken into account when restoring invaded areas.
Soils in SW Australia invaded by bridal creeper have elevated nutrient levels

Bridal creeper has increased the rate of nutrient cycling

Gradual shift of nutrient pools from biomass to the soil

Increased nutrient levels will have to be taken into account when restoring invaded areas

Sites with high conservation value need to be identified so that biological control can be used in conjunction with other restoration techniques
Acknowledgements

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We thank Karin and Carsten Richelmann for access to Quaalup Homestead and Department of Environment and Conservation (WA) for access to the other study sites.

We thank John Virtue, Anna Williams, Karen Turner, Paul Yeoh, and Touhidur Rahman for advice and field work. The staff at the Ecosystem Research Group (UWA) for advice and access to their laboratory and CSBP Laboratories for many nutrient analyses.
Some root exudates include organic acids such as found in *Asparagus officinalis* roots including caffeic, citric, furmaric and oxalic.

During decomposition of organic matter, organic acids are also released.

Oxalic acid from senescent *Salsola tragus* leaves have been shown to increase available phosphorus (Cannon et al. 1995) and suggested for *Oxalis pes-caprae* (Sala et al. 2007).