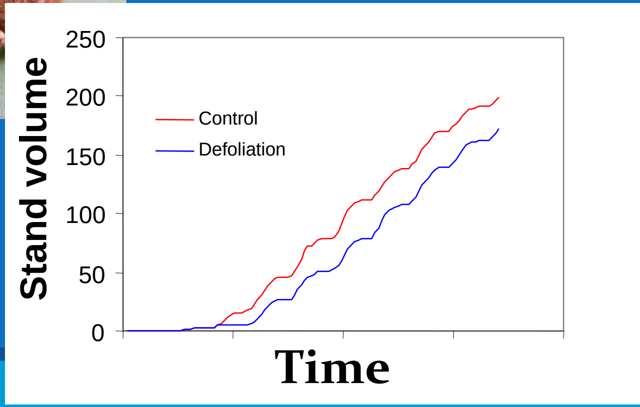
Impacts of pests on plantation productivity

Libby Pinkard



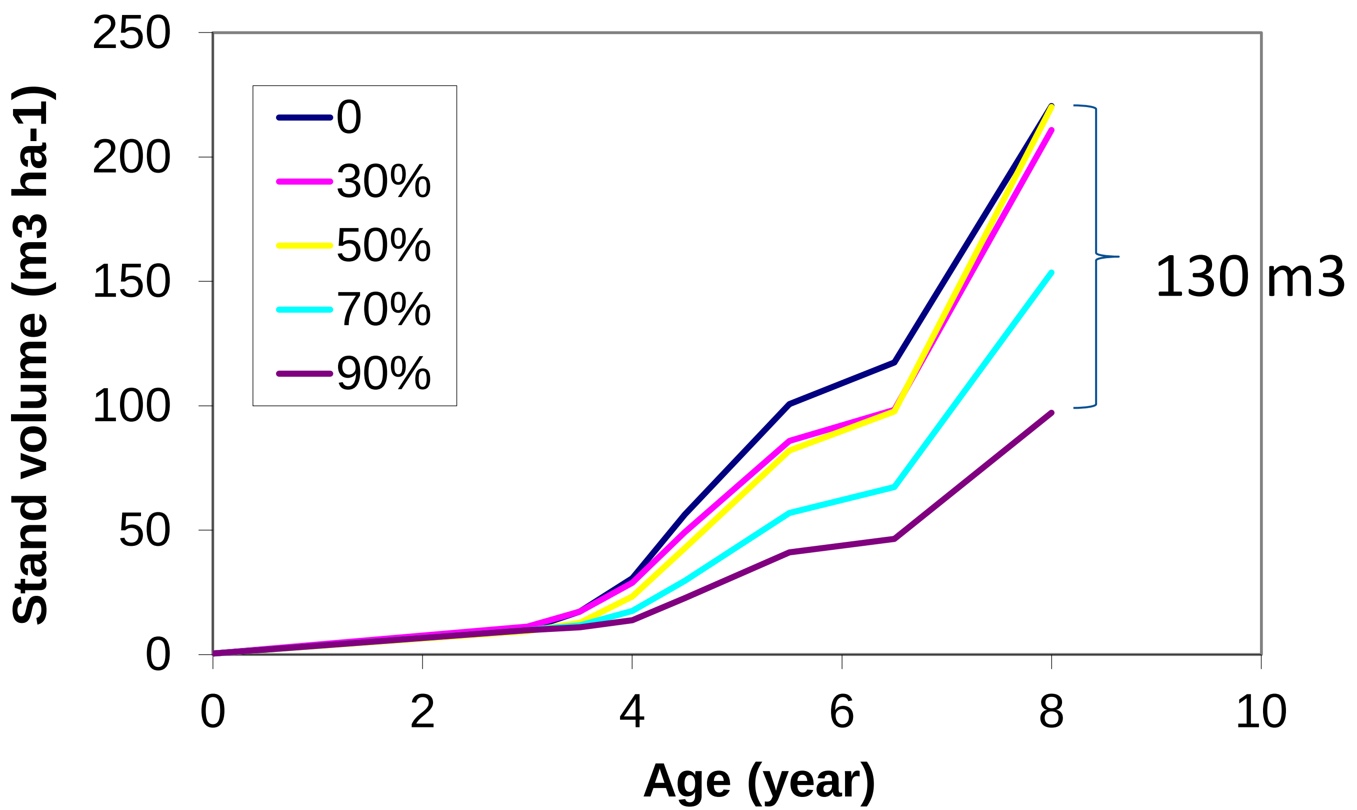
Overview

- Key pests and how they damage
- Rotation-length impact: important damage features
- Climate change:
    - Pest distribution and abundance
    - Host sensitivity and impact
    - Management strategies
- Adaptation strategies

Historical responses

- Coordinated industry response to pests that kill softwoods
  - Sirex, Ips
- Less attention paid to non-lethal softwood pests, or eucalypt pests

Does non-lethal pest attack matter?



Defoliation from Autumn gum moth, Tasmania

Key pests of temperate plantations

- 75% of key plantation pests are defoliators
- 20% are stem pests
- 5% are root pests

FWPA project:
Adaptation strategies to manage risk in Australia's plantations

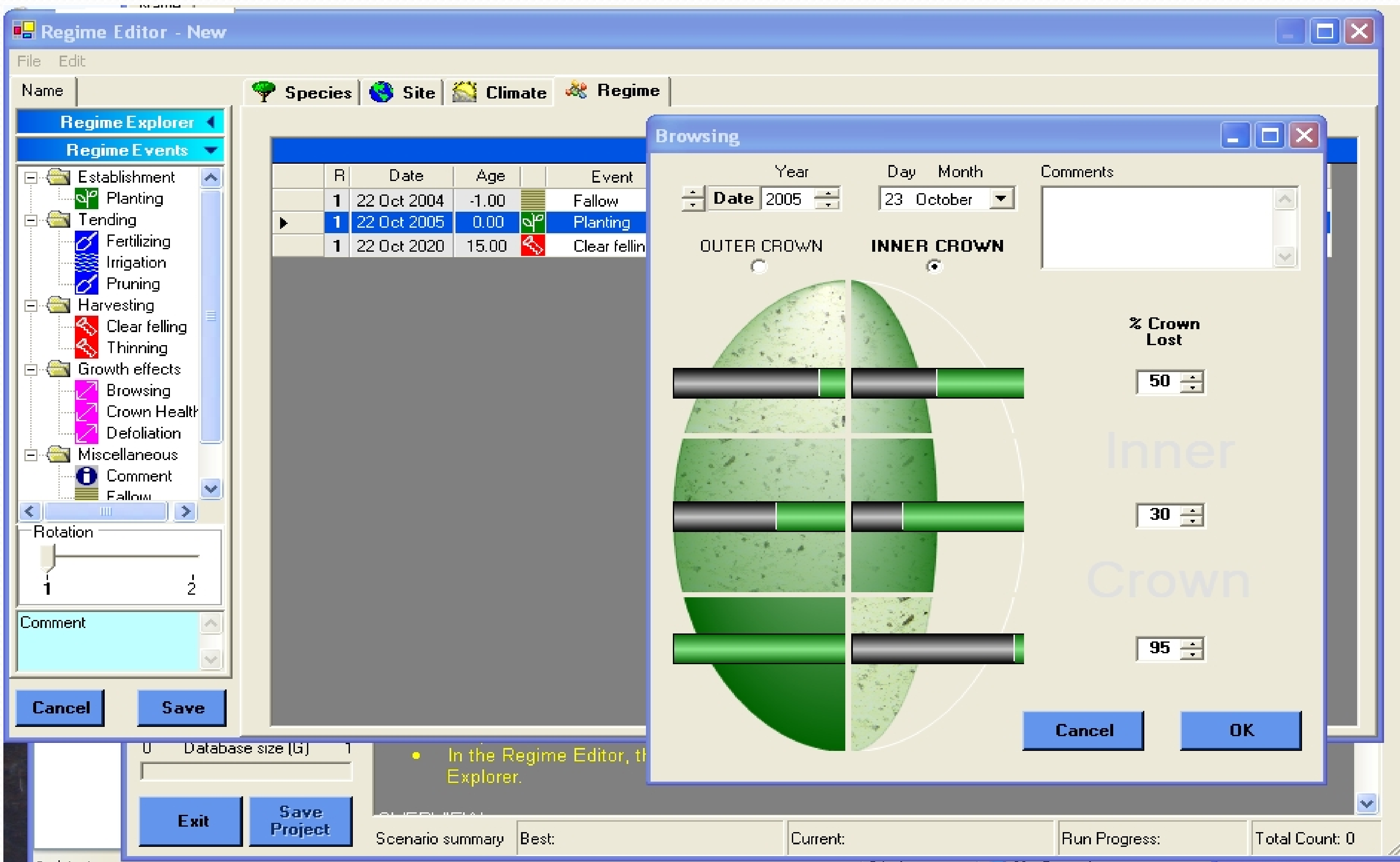
Damage features

Pest species	Susceptible stage	Season of damage	Affected organs	Foliage targeted	Defoliation pattern
Anoplognathus sp	All	SPR, SU, AUT	Leaves, shoots	Juvenile, adult	**Entire crown**
Gonipterus spp	All	SPR, SU	Leaves, shoots	Juvenile, adult	Top-down
Heteronyx spp	All	SPR, SU, AUT*	Leaves, shoots	Juvenile, adult	Top-down
Liparetrus spp	Seedlings and trees <2 yo	SPR, SU, AUT	Leaves, buds, shoots	**Juvenile**	Entire crown
Mnesampela privata	Seedlings and young trees	SU, AUT	Leaves	Juvenile	Bottom up
Paropsis, Paropsisterna, Chrysomelid spp	All	SPR, SU, AUT	Leaves, buds	Juvenile, adult	**Top down**
Uraba lugens	**All**	SPR, SU, AUT, WIN	Leaves	**Juvenile, adult**	Bottom up
Creiis lituratus	All	SPR, SU, AUT	Leaves	Juvenile	Top-down
Essigella californica#	**Post-canopy closure**	AUT, WIN, SPR	Needles	1 YO needles	Bottom-up
Cyclaneusma minus	Post-canopy closure	SPR, AUT	Needles	1 YO needles; not current needles	Entire crown
Dothistroma septosporum	All	SPR, SU	Needles	**Any age**	**Bottom-up**
Kirramyces eucalypti	All	SPR, SU, AUT	Leaves	Juvenile	Top-down
Teratosphaeria spp	Before phase change	SPR, SU, AUT	Leaves	Juvenile	Top-down
*Puccinia psidii^*	Young	SPR, SU, AUT	Leaves, tips	Juvenile	Top-down
Quambalaria spp	**Pre-canopy closure**	SPR, SU	Leaves, tips	Juvenile	Top-down

Past studies

- Generally short term – not rotation-length
- Generally young plantations
- Provided basis for modelling defoliation impacts

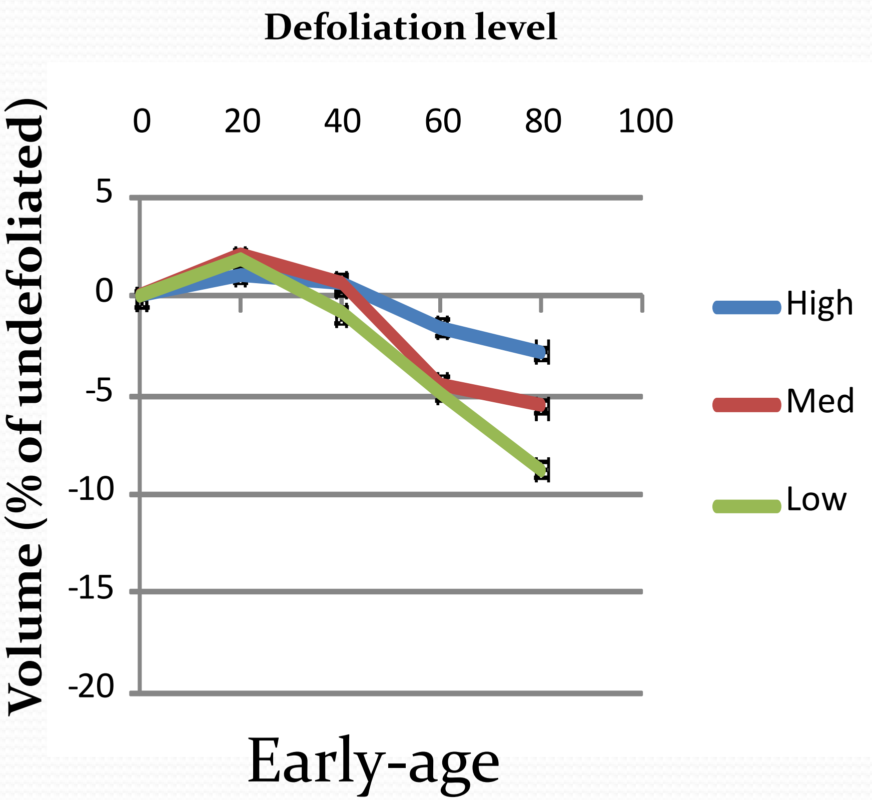
CABALA links science and application

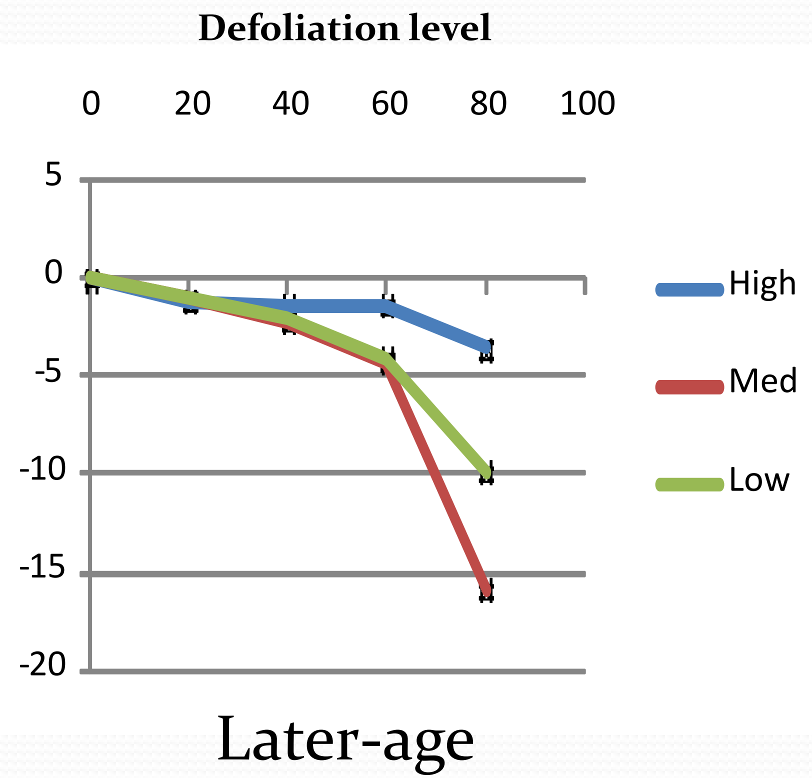


The scenarios

- High and low productivity sites selected (8 in total)
- Low, moderate and high soil fertility applied
- Standard silviculture
- Defoliation:
  - Severity: 0, 20, 40, 60, 80% leaf/needle loss - THRESHOLDS
  - Early *vs* later-age
  - Bottom-up *vs* top-down
  - Single *vs* chronic
  - Spring *vs* autumn
- Average of 20 model runs per scenario

Thresholds: *E. globulus*

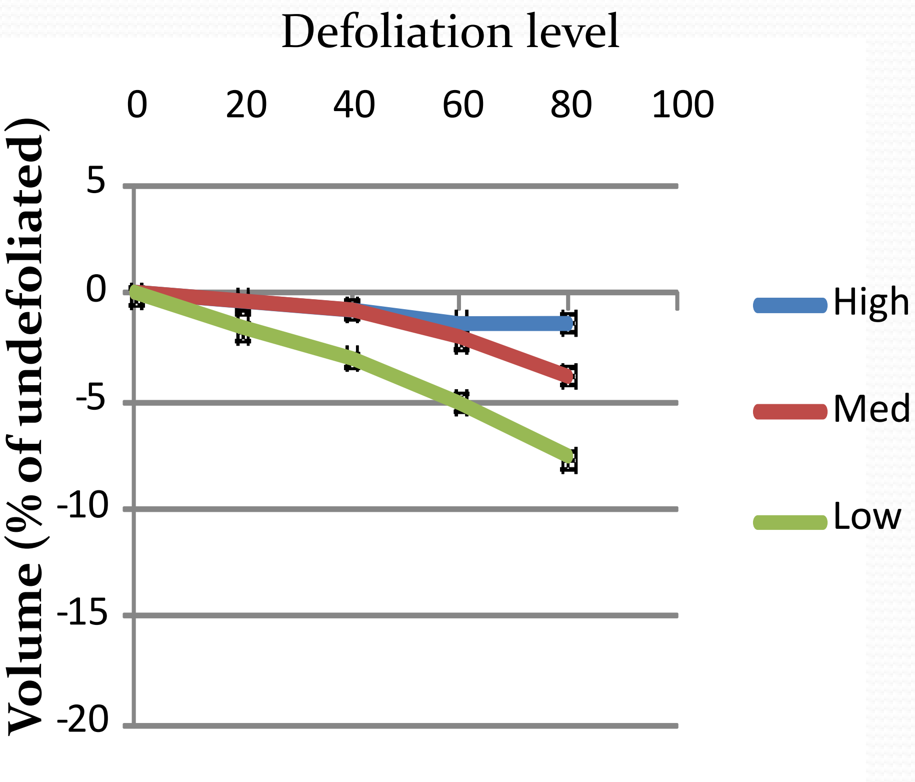




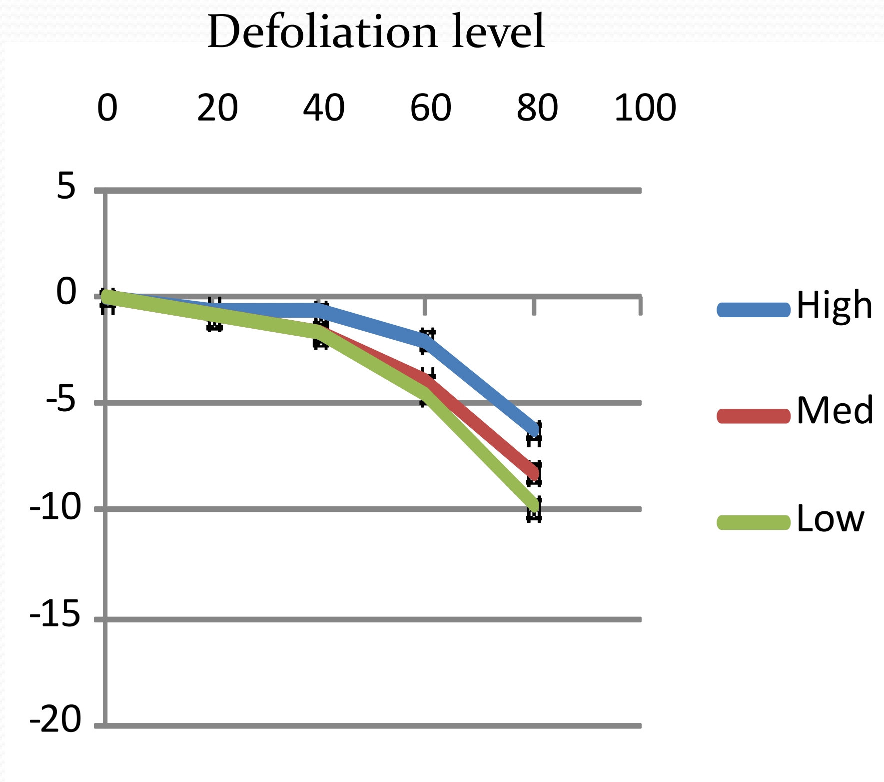
State	Productivity	Defoliation threshold*					
		Early			Later		
		High	Mod	Low	High	Mod	Low
SA-GT	lower	-	-	60%	-	60%	60%
SA-GT	higher	-	-	60%	-	60%	-
SW WA	lower	-	-	-	-	70%	70%
SW WA	higher	40%	-	-	-	70%	70%
Tas	lower	60%	40%	40%	70%	70%	-
Tas	higher	60%	60%	60%	60%	60%	60%
Vic-NSW	lower	50%	60%	60%	70%	70%	70%
Vic-NSW	higher	50%	60%	60%	60%	50%	60%

*level of defoliation that results in 5% reduction in harvest volume

Thresholds: *P. radiata*



Early-age



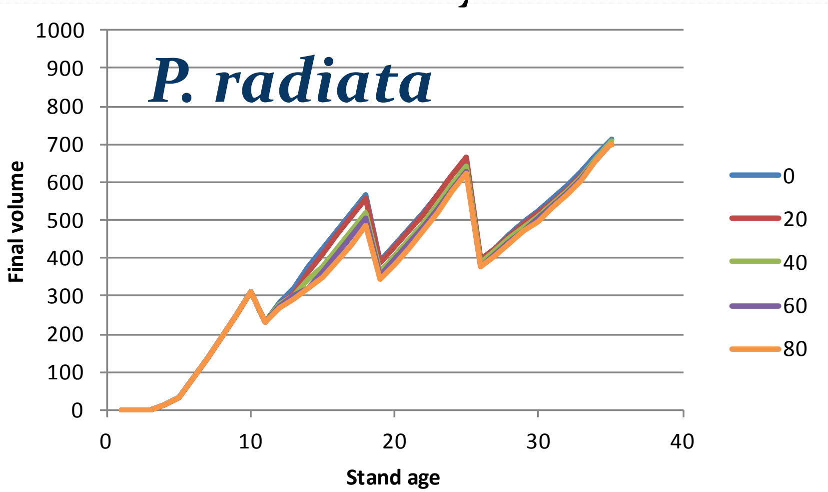
Later-age

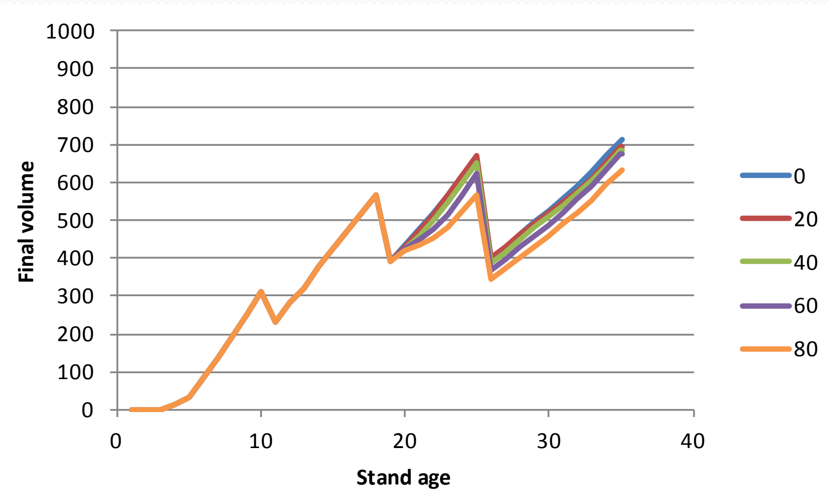
State	Productivity	Defoliation threshold					
		Early			Later		
		High	Mod	Low	High	Mod	Low
SA-GT	lower	-	-	60%	70%	60%	60%
SA-GT	higher	-	-	60%	80%	75%	65%
SW WA	lower	-	-	60%	80%	75%	60%
SW WA	higher	-	-	60%	-	75%	65%
Tas	lower	-	-	60%	-	-	60%
Tas	higher	-	-	70%	-	70%	65%
Vic-NSW	lower	-	-	70%	80%	65%	60%
Vic-NSW	higher	-	-	80%	80%	75%	65%

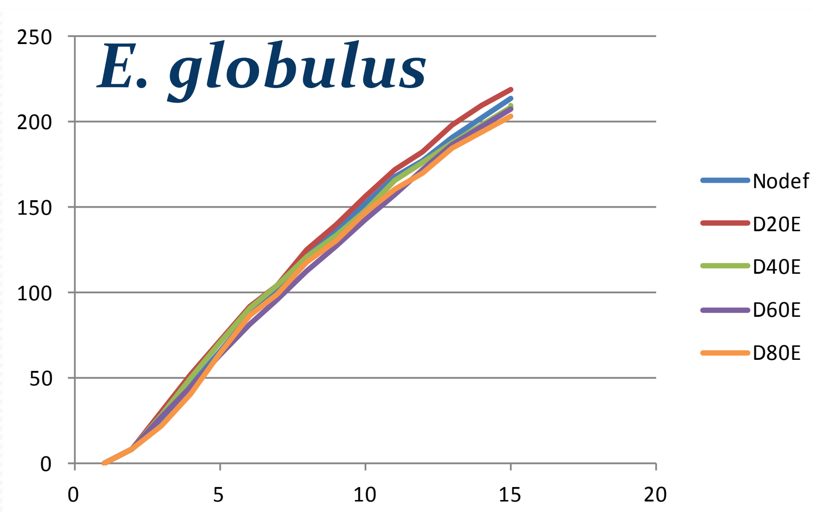
Defoliation age

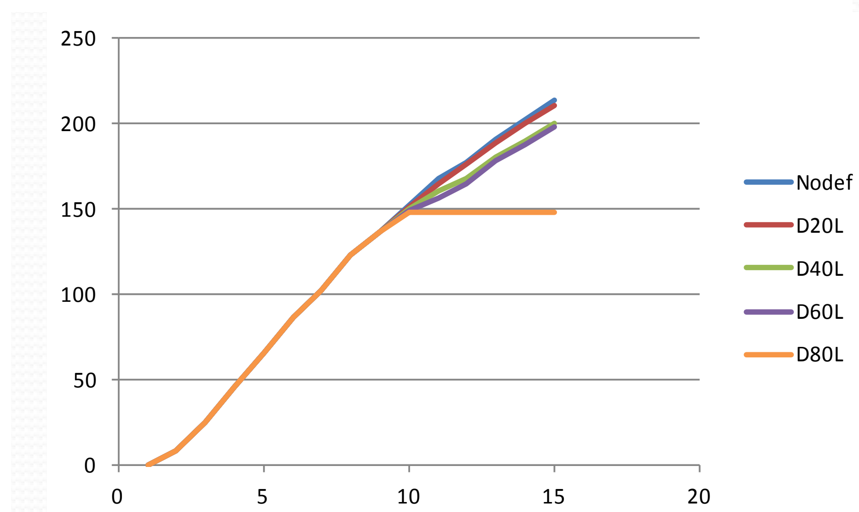
Early

Later

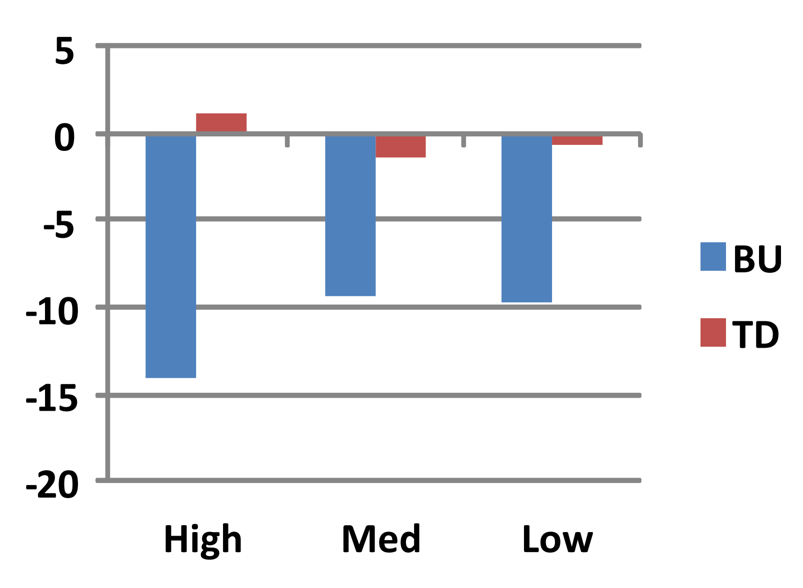


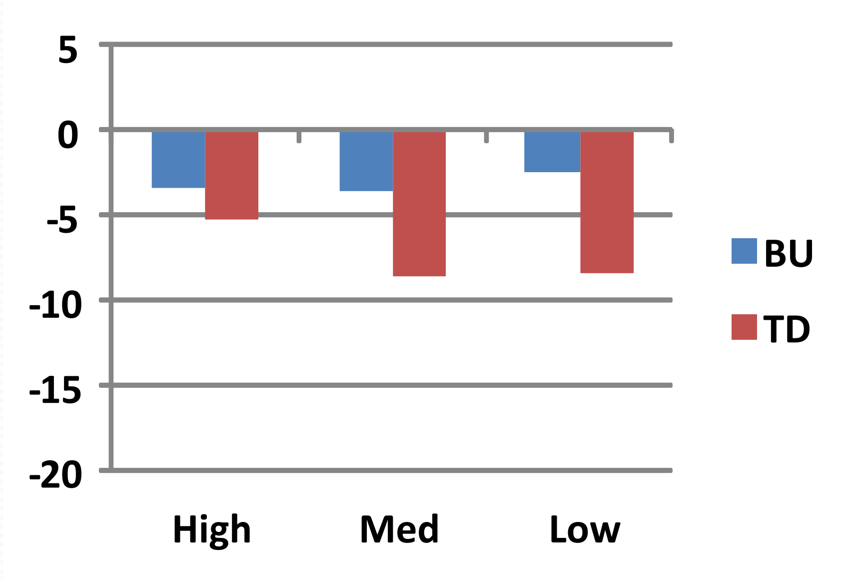




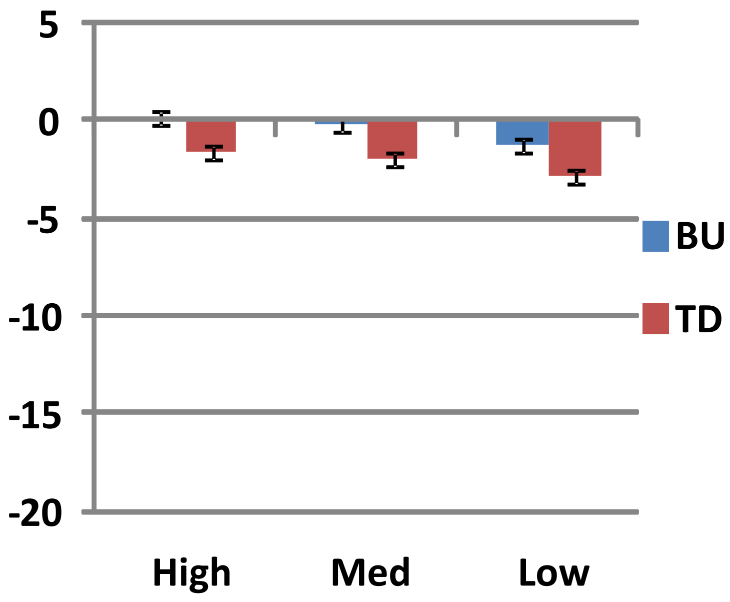


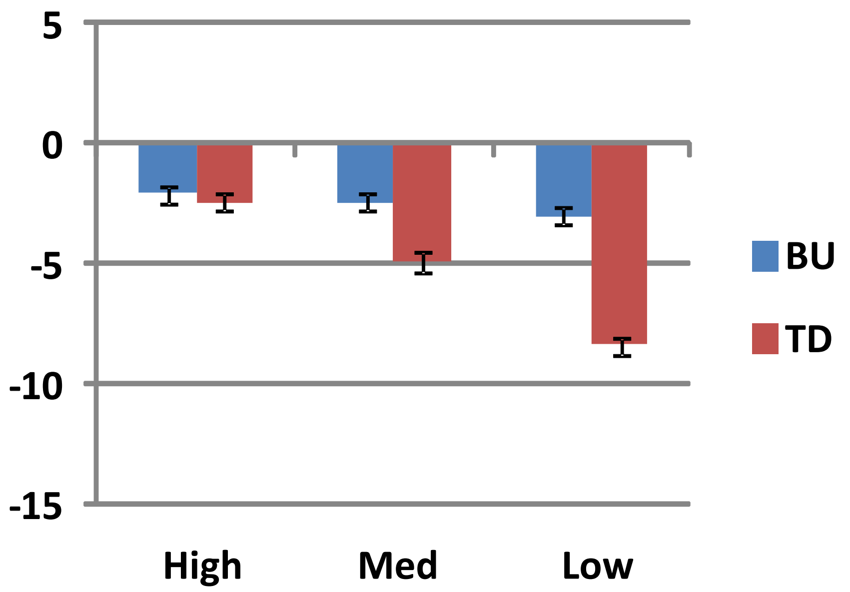
Defoliation pattern: *E. globulus*



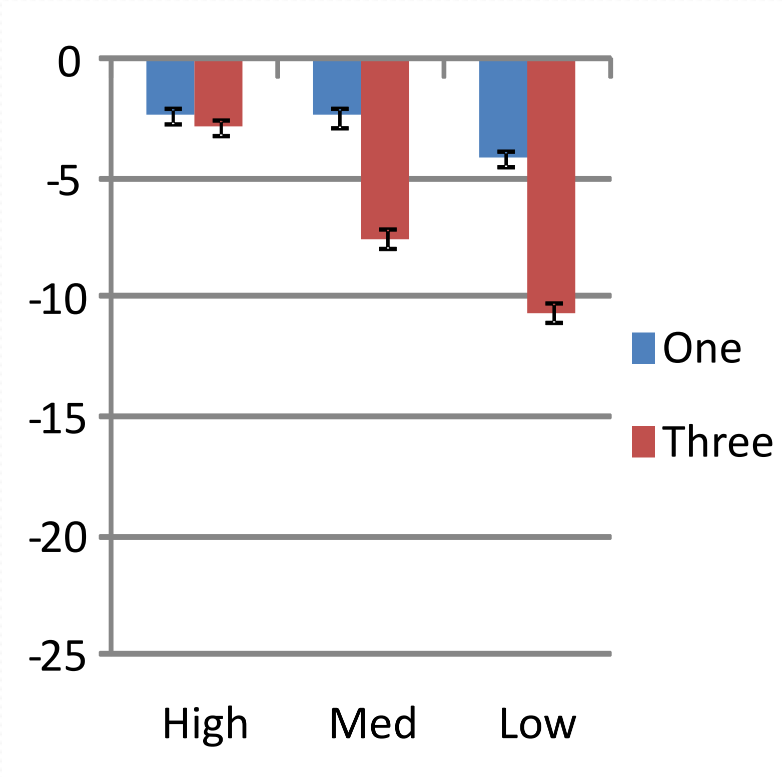


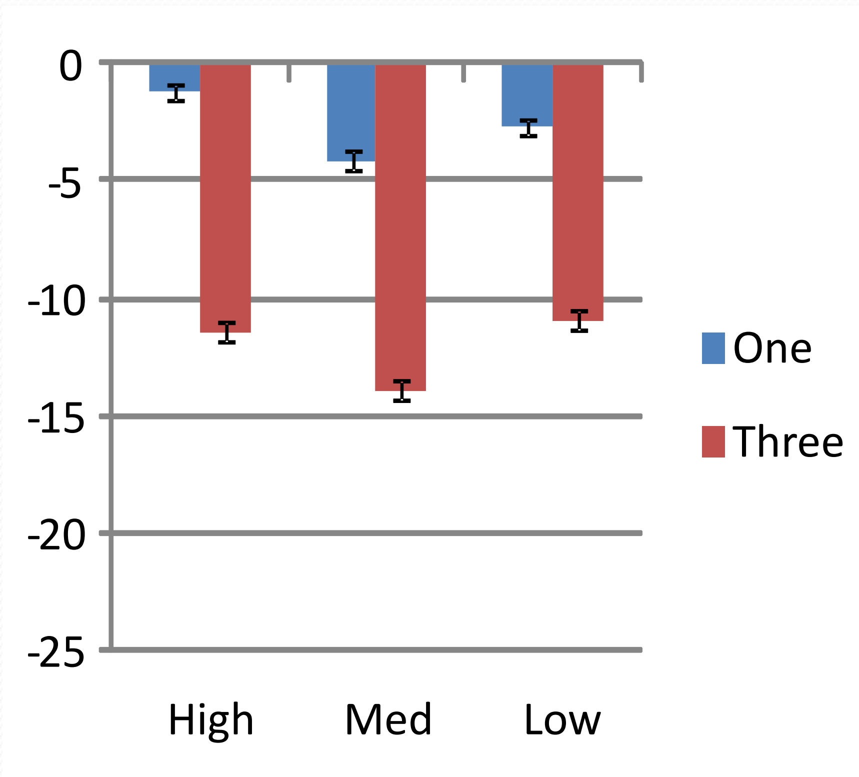
Defoliation pattern: *P. radiata*



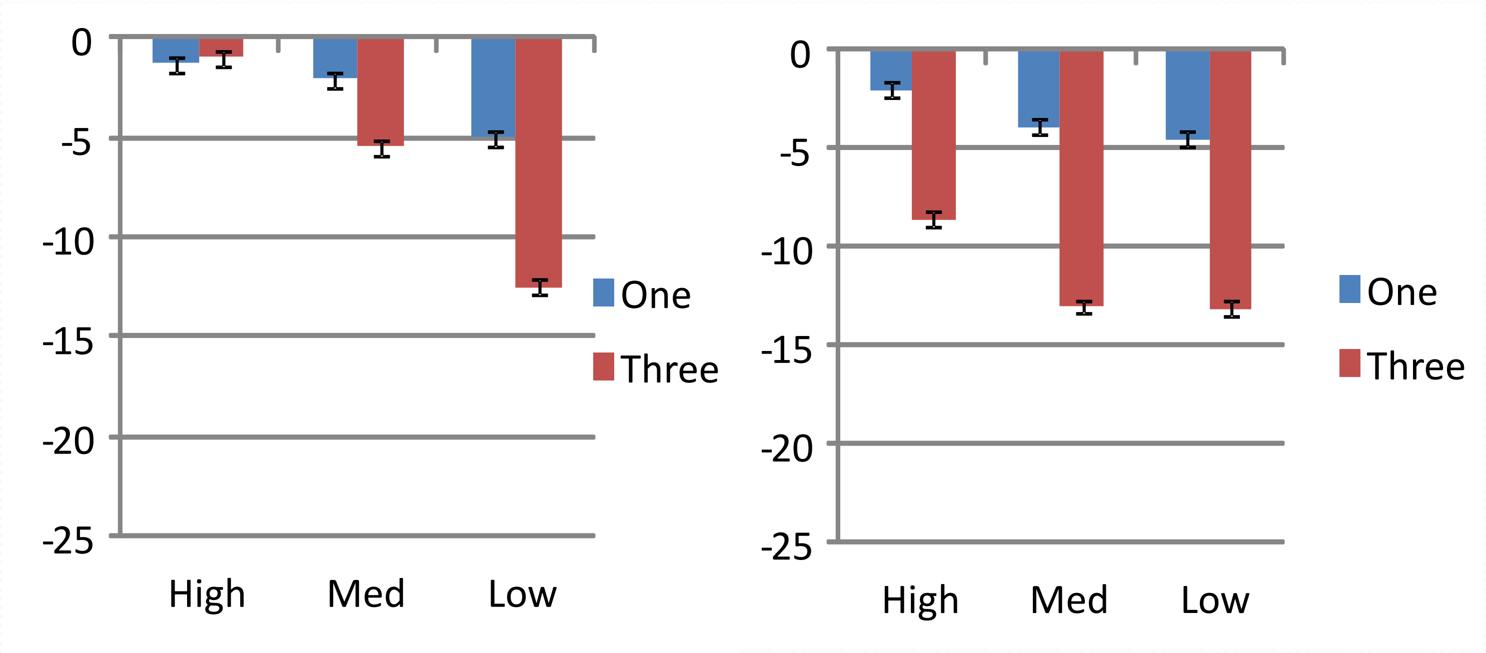


Defoliation frequency: *E. globulus*





Defoliation frequency: *P. radiata*



Summary

- Later age of more concern than early age
- Top-down generally of more concern – although bottom up for young *E. globulus*
- Single defoliation events generally of less concern than multiple events
- Defoliation thresholds:
  - Between 20 – 40% defoliation reduces stand volume
  - What is the economic threshold?

Climate change

Phenomenon and direction of trend	Likelihood that trend occurred in late 20th century	Likelihood of future trend based on projections for 21st century
Warmer/fewer cold days/nights over most land areas	**Very likely**	**Virtually certain**
Warmer and more frequent **hot days/nights** over most land areas	**Very likely**	**Virtually certain**
Increased frequency of **heatwaves** over most land areas	**Likely**	**Very likely**
Increased frequency of **heavy precipitation** events	**Likely**	**Very likely**
Increased area affected by **drought**	**Likely** in many regions since 1970	**Likely**
Increased intense **tropical cyclone** activity	**Likely** in many regions since 1970	**Likely**

Implications for plantation productivity

Impact	Possible outcome
Warmer MAT	Change in **seasonality** of growth and increase in length of growing season
	Increased **pest damage**
	Reduced **frost** hardening and increased susceptibility to frost
	Increased transpiration and evaporation resulting in increased **water stress**
	Increased rates of **photosynthesis** that may increase growth rate
Increased frequency of heatwaves	Tissue damage, protein denaturation and **mortality**, particularly if combined with drought
	Greater soil evaporation leading to increased plant **water stress**
	Greater **post-establishment mortality**
Increased drought conditions	Reduced **leaf area index** and therefore decreased growth rates
	Tissue damage and **mortality**
	Greater susceptibility to some **pests** e.g. stem borers
	Greater post-establishment **mortality**
Elevated atmospheric CO_2	Increased **growth** where water and nutrients are non-limiting
	Increased allocation of **biomass** below-ground
	Greater **water-use efficiency** that may reduce drought effects

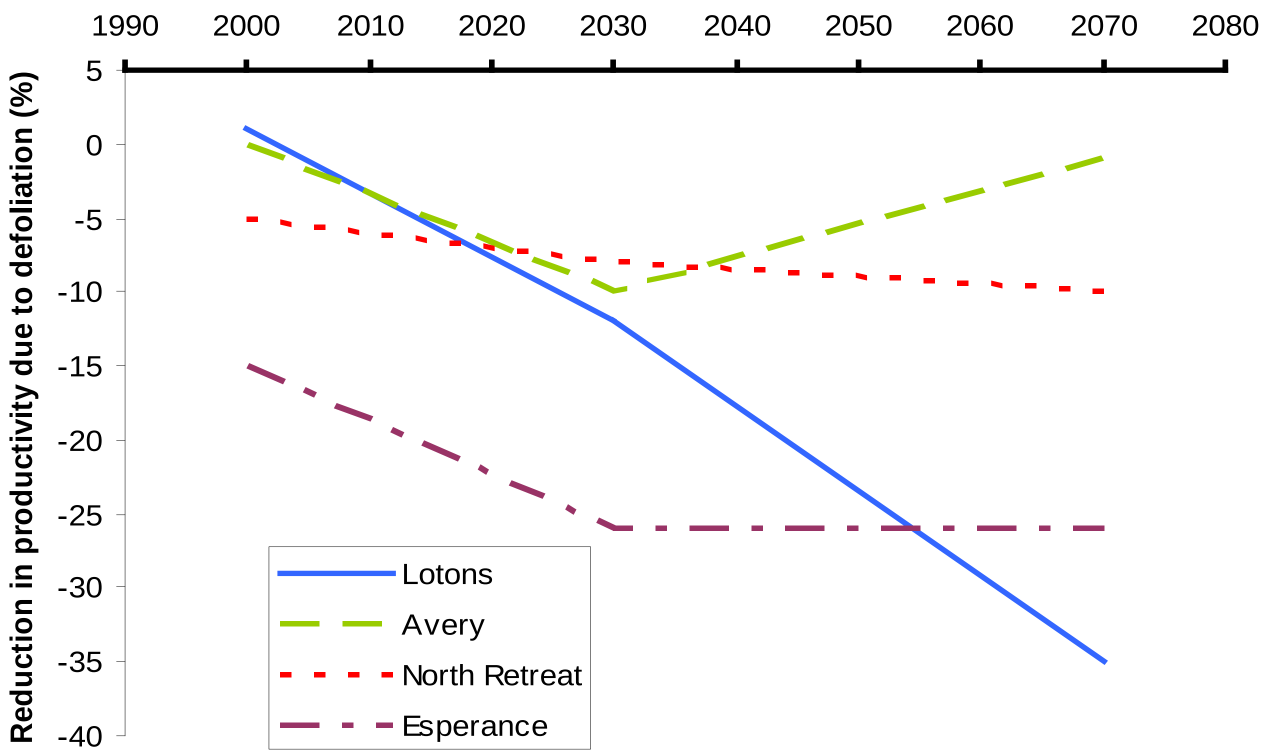
Implications for pests: distribution, activity, damage

Impact	Potential outcome
Warmer MAT	Increased number of **insect generations** per year
	Decreased **winter mortality** resulting in more rapid population build-up
	Increased **late-season damage** resulting in potentially greater impact on growth
	Range shifts to higher latitudes and elevations
Decreased precipitation	Increased risk from pests such as **stem borers**
	Possible decreases in risk from **foliar pathogens**
More extreme precipitation events	May favour **foliar pathogens** if high relative humidity occurs
	May wash **insect**s and larvae from leaves
More variable precipitation	May favour some **root pathogens** e.g *Armillaria* spp
Elevated CO_2	Increased development and **reproductive rates** in some insect guilds
	Increased fecundity and aggressiveness in some necrotrophic and biotrophic fungi

What we don't know…

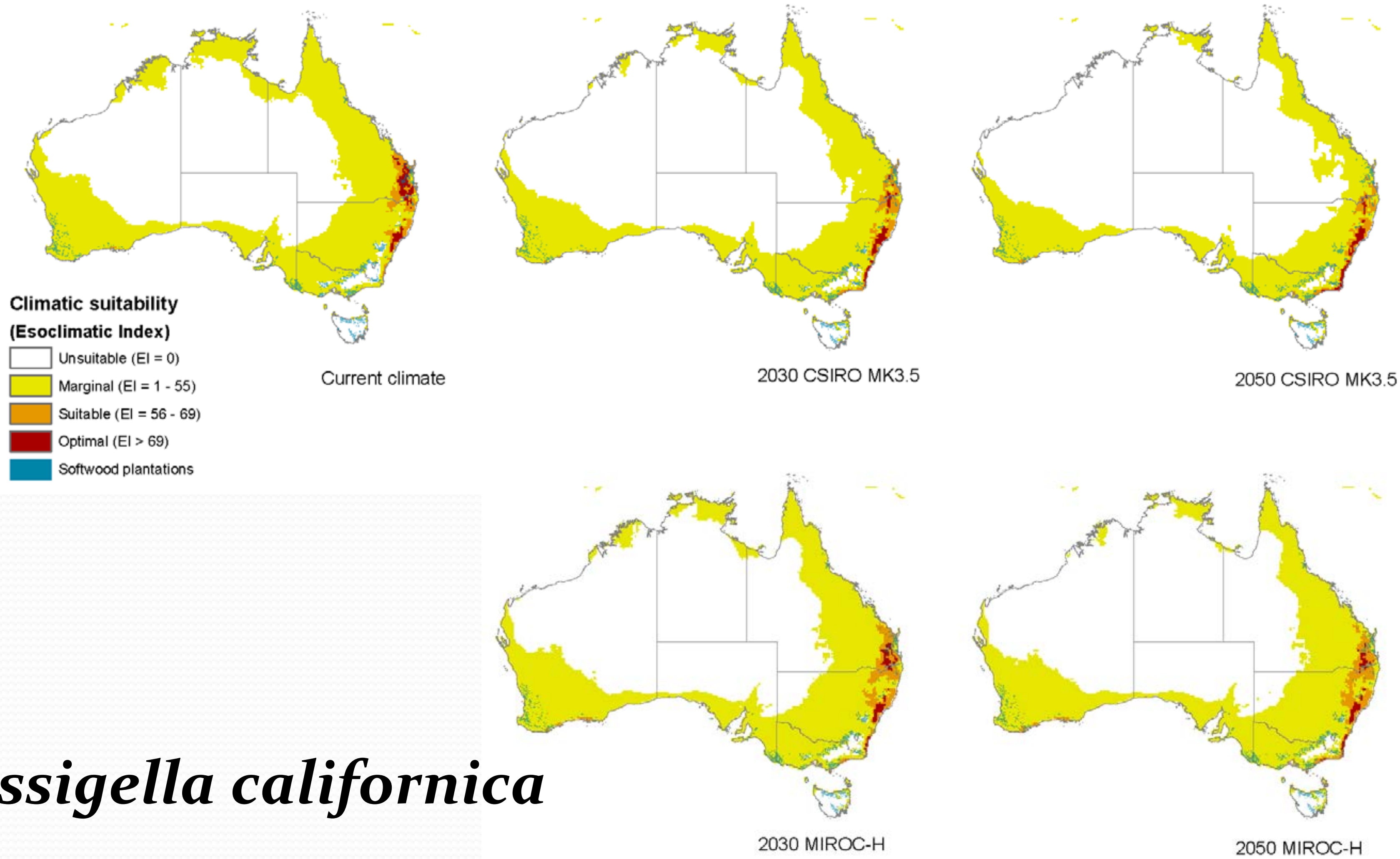
- BUT trees may produce more defence compounds because of increased CO_2
- So levels of damage may be less than anticipated
- Complex host-pest interactions

Impact may increase



Pinkard et al 2008. Climate change and Australia's plantation estate: pest impacts on carbon stores. Report to the Australian Greenhouse Office

Distribution and abundance



Essigella californica

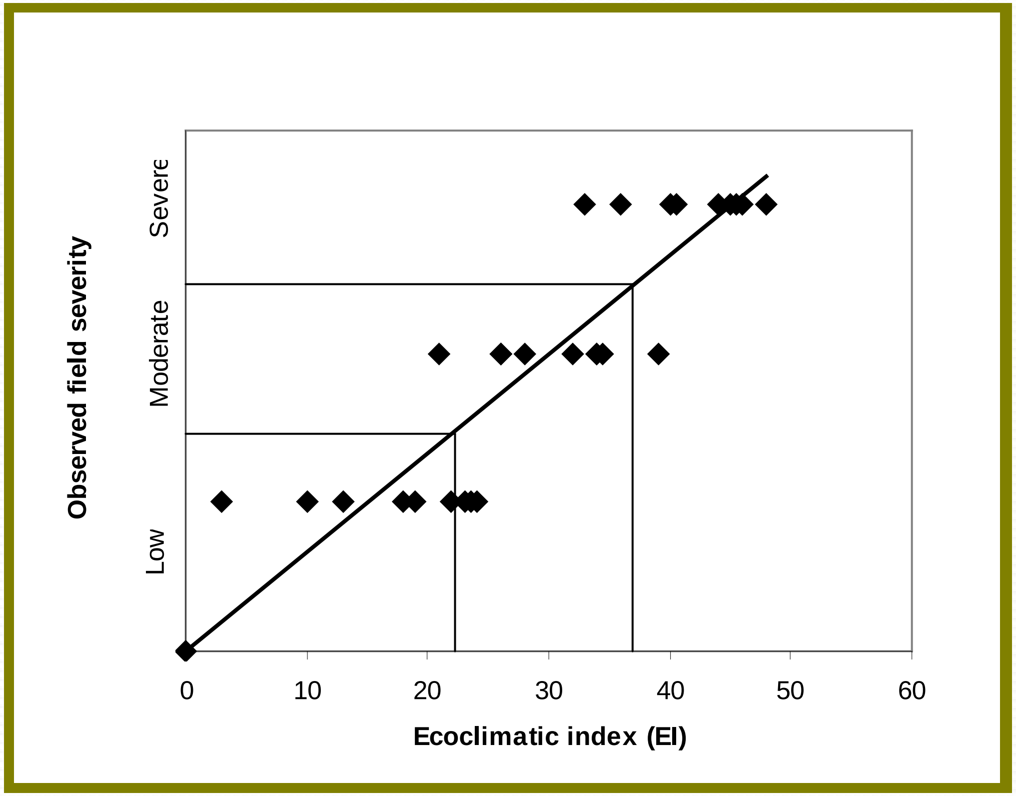
Climatic suitability: eucalypt pests

Pest species	Climatic suitability class	Area of estate in each class (ha)	% of estate in each class				
			Current	2030		2050	
				CSIRO 3.0	Miroc-H	CSIRO 3.0	Miroc-H
Eucalypt pests							
Autumn gum moth	Unsuitable	245258	9	16	15	24	17
	Marginal	12138	5	3	2	3	4
	Suitable	101693	37	39	35	35	31
	Optimal	129976	48	40	47	38	48
Mycosphaerella leaf disease	Unsuitable	50591	19	13	11	13	11
	Marginal	125895	46	54	44	54	39
	Suitable	76103	28	26	36	27	40
	Optimal	15743	6	6	8	6	9
Eucalypt rust	Unsuitable	188510	70	70	69	70	69
	Marginal	13057	5	5	2	11	3
	Suitable	42078	15	20	20	16	20
	Optimal	24687	9	4	8	2	7
Gum laef skeletonzer	Unsuitable	184706	68	68	68	76	65
	Marginal	16963	6	15	9	10	17
	Suitable	6855	26	5	8	8	4
	Optimal	59808	22	11	15	5	14
Total eucalypt estate		268332					

Climatic suitability: pine pests

Pest species	Climatic suitability class	Area of estate in each class (ha)	% of estate in each class				
			Current	2030		2050	
				CSIRO 3.0	Miroc-H	CSIRO 3.0	Miroc-H
Eucalypt pests							
Pine pests							
D. septosporum	Unsuitable	8483	0.8	2	1.5	4	2
	Marginal	25540	3	5	3	6	3
	Suitable	398103	40	56	35	58	38
	Optimal	545963	56	37	61	31	57
E. californica	Unsuitable	288284	29	15	19	7	13
	Marginal	541592	55	70	69	89	76
	Suitable	79204	8	14	9	4	9
	Optimal	69208	7	0.07	2	0.01	0.05
S. noctilio	Unsuitable	14467	1	3	3	5	3
	Marginal	10816	1	0.02	0.02	1	0.01
	Suitable	326003	33	30	24	32	20
	Optimal	626802	64	67	73	62	77
Total pine estate		978089					

Linking risk to impact



Mycosphaerella leaf disease

Frequency of outbreaks

Species	Severity rating	Ecoclimatic index	Anticipated severity of defoliation	Frequency (% of years)
Teratosphaeria	Low	0-24	0-30%	20
	Moderate	25-37	30-60%	60
	Severe	38+	60+%	80
E. californica	Low	0-55	0-10%	30
	Moderate	56-69	10-50%	60
	Severe	>69	50+%	100

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Summary

- Large uncertainties about how climate change will affect hosts and pests
- Site-specific assessments probably required to understand impact
- Tools for understanding changes in risk and linking to impact
- Monitoring pests and health assessment of hosts critical for understanding risk and impact of climate change

Adapting to change

<table>
<tr><th>Strategic</th><th>Operational</th></tr>
<tr><td>Industry-wide pest monitoring network</td><td>Use IPM to identify control measures</td></tr>
<tr><td>Develop pest distribution and damage database</td><td rowspan="2">Regular pest monitoring</td></tr>
<tr><td>Profile potential new pests</td></tr>
<tr><td rowspan="5">Tools for assessing risk and impact and ways of building resilience</td><td>Manage risk (eg species choice) or avoid high risk sites</td></tr>
<tr><td>Maintain plantation resilience through management:
-spacing, fertilising, species choice</td></tr>
<tr><td>Promote recovery with spacing, fertilising, weed control</td></tr>
<tr><td>Control pests when thresholds are exceeded</td></tr>
<tr><td>Define operational windows for control</td></tr>
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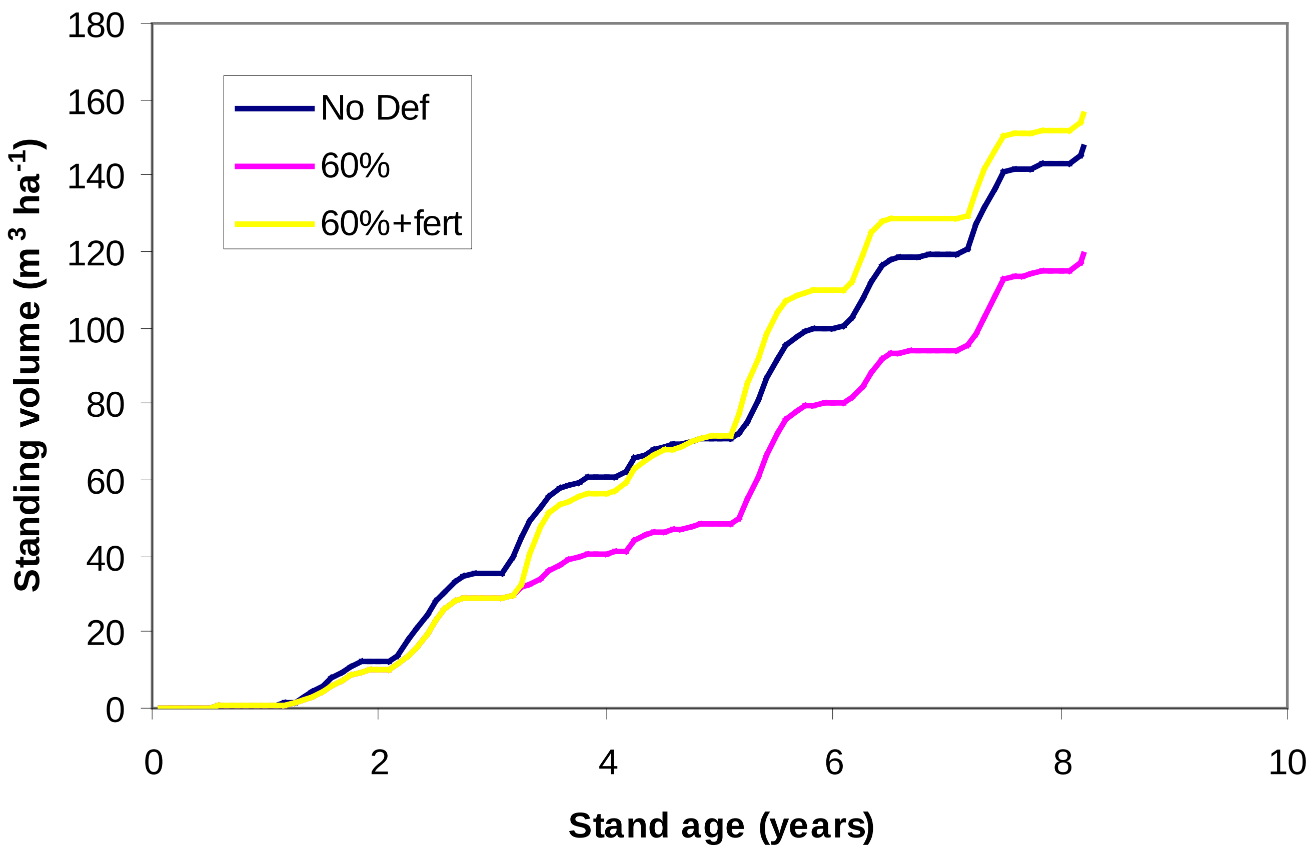
Promoting recovery: fertilising



Final thoughts

- Good tools available for exploring defoliation impacts
  - Site level
  - Reports
  - Databases
- Regional discussions of risks and impacts of climate change
- Regular updating required as information improves/changes

Thank you

CSIRO Ecosystem Sciences
Dr. Libby Pinkard

t +61 3 6237 5656
e Libby.Pinkard@csiro.au
w www.csiro.au