Win-Win Weed Control: The Economics of Weed Biocontrol

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Weeds in NZ

- Since 19th century, at least 25,000 exotic species introduced (10% of world's flora), 90% deliberately.
- A species naturalises every 39 days.
- Now more naturalised than native species.
- ~500 species considered weeds at present.


Japanese honeysuckle


Tradescantia


Giant buttercup


Field horsetail

Biocontrol as an option

- Exotic weeds such as heather in TNP can be targeted by biological control

Alternatives to Weed Biocontrol

- Eradication: yes, do it if you can
- Appealing, but seldom an option unless the weed has only just arrived in NZ (and further arrivals are unlikely)
- Worldwide – lots of v. expensive failures
- Other control methods can work: herbicides, mechanical etc
- But these are frequently too expensive (especially in perpetuity), ineffective and/or have unacceptable non-target effects

Weed Biocontrol

- Positives:
- When successful it is sustainable, safe and cost-effective in the long term
- Biocontrol negatives (esp. for new programmes):
- Substantial upfront investment of $$
- Uncertainty of outcome
- Long time frame for success
- Need convincing benefit:cost analyses

Weed Biocontrol

- Until recently, NZ has relied on overseas benefit:cost analyses of weed biocontrol
- And some remarkable overseas successes: monumental – literally!

- Paucity of relevant data in NZ on historic extent and impact of weeds; biocontrol costs/impacts

Case study: St John's Wort

- St John's What?
- *Hypericum perforatum*
- Major pasture weed in 1930s

- Biocontrol by *Chrysolina* spp beetles – huge success for NZ
- Limited evidence: fertile ground for sceptics
- Controlled early before it has spread far – no data on costs

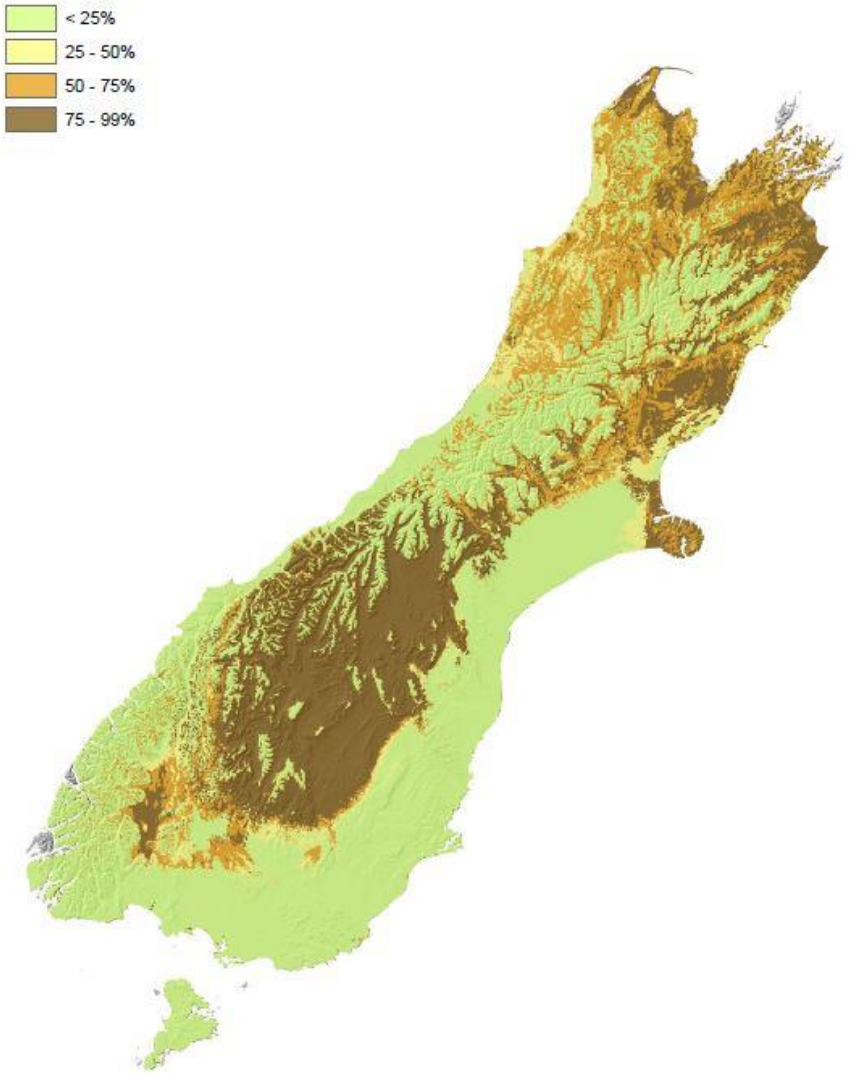
St John's Wort – Demonstrating Success

- Past evaluation patchy
- Insecticide exclusion studies

- Compelling, high-quality evidence of success

St John's Wort: Predictions of Spread

- Expanding its distribution in 1920s
- How bad would it have become?
- Eco-climatic modelling, based on distribution of early, serious infestations



St John's Wort: Biocontrol Economics

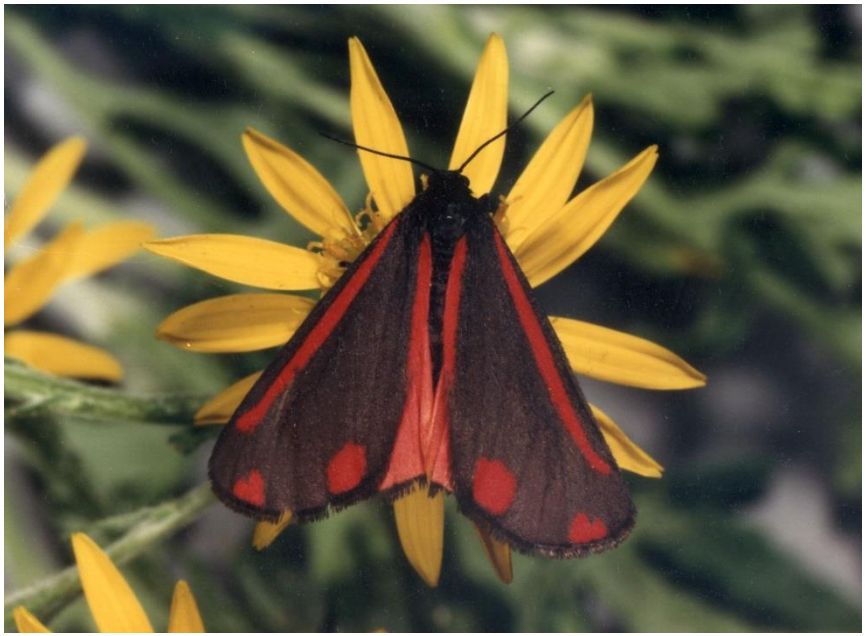
- Losses: pasture displacement on low value land
- Biocontrol costs (1940-60)
- NZ better off now by $150m-$1490m (net present value) from SJW biocontrol (slow-fast spread scenarios)
- Even lower figure more than covers all costs of weed biocontrol in NZ
- Key assumptions e.g.:
- Spread of weed post 1920s, and associated impact
- SJW not replaced by an equally serious weed

Case Study 2: Ragwort, *Jacobaea vulgaris*

- Major pasture weed – spread into all areas >800mm annual rainfall by 1930s
- No further spread modelling needed
- Displaced pasture and poisoned stock

Biological Control of Ragwort

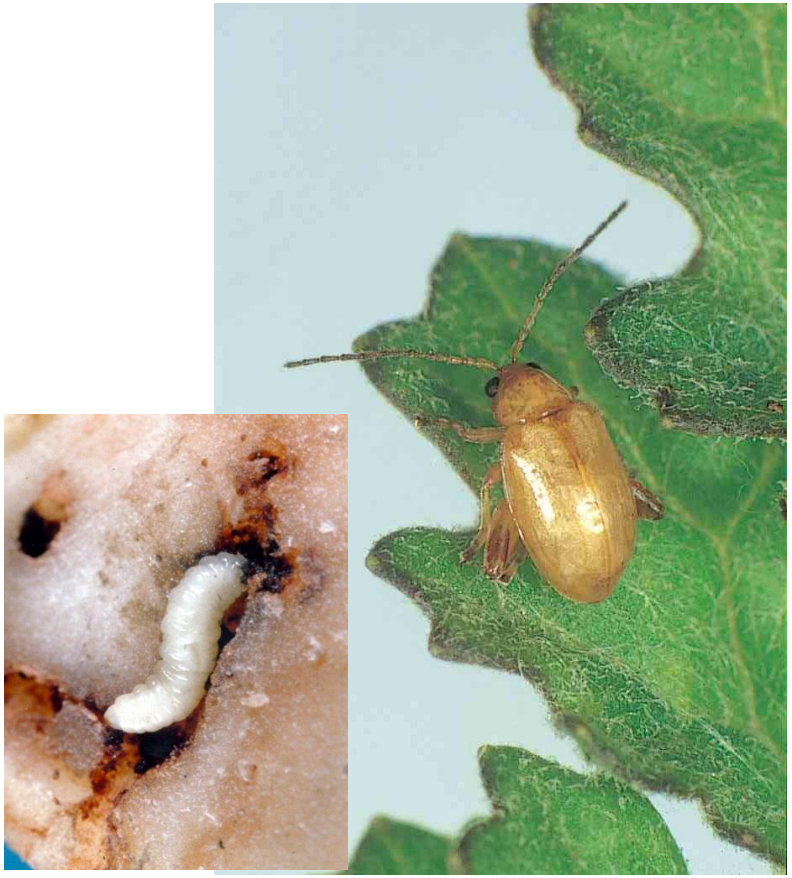
- Pioneered by NZ: Cinnabar moth and seed fly established in 1930's



- Both ineffective
- Programme ceased – weed remained a serious problem

Biological control revisited

- USA/Australia 1960/70s: success with ragwort flea beetle
- NZ followed in 1983: also successful



- In NZ, only anecdotal data on impact and no assessment of economic benefit

Beetle didn't succeed everywhere

- Control failed in high rainfall areas
- Research → Beetle rare where rainfall >1700 mm/yr
- NZ released ragwort plume moth, 2005; better adapted to wet areas

- Release application included a cost-benefit analysis from the West Coast where biocontrol was failing

Expanding on the Economic Survey

- Survey: Control costs (labour + herbicide) on 32 dairy farms on West Coast (where biocontrol ineffective)
- Mean ragwort control per farm = $2789 in 2005
- Now extrapolate to all 12000 dairy farms in NZ i.e. control costs if biocontrol hadn't happened
- 2005 data adjusted for avg. inflation (3%/yr) and national herd size (1926: 2.3m → 2015: 6.8m)
- Without biocontrol, NZ dairy farms would have spent $64m on ragwort control in 2015
- Now need to know benefit from biocontrol, and costs of the biocontrol programme (1920s - 1990s)

Benefit from Ragwort Flea Beetle

- Collated all trial data 1980s to present
- Mean ragwort density in season 1 (no flea beetle) compared with mean density in final year of trial

Trial Data - % change in ragwort density

Horomanga	Bay of Plenty, NI	–100%
Orere Point	Hunua, NI	–100%
Carterton	Wellington, NI	–100%
Turakina	Wanganui, NI	–100%
Alcove	Kaipara, NI	–100%
Sisam	Bay of Plenty, NI	–100%
McCann	Bay of Plenty, NI	–100%
Hampden	Otago, SI	–100%
Pahiatua	Wanganui, NI	–96%
Woodside	Otago, SI	–96%
Leader River	Canterbury, SI	–82%
Turakina	Wanganui, NI	–68%
Nettingham	Bay of Plenty, NI	–33%
Larkin	Taranaki, NI	–20%
Tukituki River	Hawke's Bay, NI	21%
Ward Rd	Southland, SI	38%

50% of trials: ragwort eliminated

25% of trials: mean reduction of 86%

25% of trials: <50% reduction (or increase) – assume zero benefits

Benefit from Biocontrol

- Extrapolated nationally from these trials
- 100% reduction (6220 farms), 86% (3110), 0% (3110)
- Conservative assumptions:
- Benefit started 7 years after beetle release in 1983
- Increased at 10% per year to maximum by 1999
- Ragwort flea beetle saved dairy farmers $44 million in 2015 in reduced ragwort control costs – with savings per year now ongoing

Biocontrol Costs

- No past cost data, but very detailed descriptions of activities
- Used equivalent costs of modern programmes, inflation-adjusted back to 1920/30s for first two agents, and to 1980s for the flea beetle.

Benefit:Cost Ratio

- All past costs (or benefits) are inflated at 8%/yr to add higher value to past $$ spent or saved (net present value)
- For ragwort biocontrol the benefit:cost ratio is 14:1 (i.e. every $ spent has generated $14 in savings)
- Only considers control costs – not losses in productivity (no data)
- Major assumption on lack of replacement weeds

Retrospective/Reflections

- NZ rejected flea beetle in 1930s based on field observations, and advice from a botany professor, rather than experimental trials
- This rejection cost NZ $8.6 billion (NPV) from the 1940s to 1999 – which could have been avoided with a bit of investment in some science!
- Do the science; don't give up too easily!
- Research into flea beetle failure in wet areas led to the plume moth release – potentially saving a further $20m/yr

Source: Fowler et al. 2016. Biological control of ragwort in the New Zealand dairy sector: an ex-post economic analysis. NZ Journal of Agric Research 59, 205-215

No Replacement Weeds?

- Seems obvious that SJW and ragwort monocultures have not been replaced by comparable weeds – but no hard data
- Good data for SJW in California in 1950s, and for mist flower in NZ in 1998-2003 showing limited replacement weeds
- Replacement weed seem to be especially problematic with aquatic weeds
- One benefit:cost study in NZ does include replacement weeds: Alligator weed

Alligator Weed
(*Alternanthera philoxeroides*)


Pararaha wetlands,
Waitakere Ranges


Agasicles hygrophila


Arcola malloi

Alligator Weed Biocontrol

- Weed in both productive sector and the environment
- Biocontrol only a limited success – agents require aquatic systems with limited water level changes and lack of frosts
- But unusually well-documented after introductions in early 1980s
- Recently re-visited to do benefit:cost analysis

Alligator Weed Economics

- Farm ponds: cleared of alligator weed every 7-8 years, reduced to 10-12 years (other weeds)
- Cost $500 per clearance, 100 dams in Hobson District. 10 similar districts Auckland northwards.
- Avg/yr: (500/7.5)x100x10 = $67000
- 10-12 years - costs (500/11)x100x10 = $45500
- Biocontrol saves $21500/yr, but replacement weeds cost $45500/yr
- Drains: savings $190000 - costs still $2.65m because biocontrol mostly ineffective in flowing water

Source: Philip BA et al. 1988. Current status of biological control of alligator weed in New Zealand. Proc 41st NZ Weed & Pest Control Conf pp 61-65

Alligator Weed Analysis

- Inflation adj: control costs +/- biocontrol, and estimated biocontrol costs
- In 2016 biocontrol saved $505K but costs still $6.47m/yr (Auckland northwards) – 8% saving
- NPV gives benefit:cost of 101:1
- Even a little biocontrol can be economically highly beneficial – and biodiversity gains would also be large in ponds and lakes

Valuing Environmental Benefits

- Contingent valuation – old man's beard

Valuing Environmental Benefits

- Contingent valuation: willingness to pay (WTP) to prevent environmental degradation
- 3000 people surveyed with photos of invaded and uninvaded bush – and asked about WTP extra tax to fund biocontrol of OMB
- Extrapolated to all NZ public: willing to pay $44-111m for a “relatively small” chance of controlling OMB biologically
- Various biases possible due to naivety and is this the right question?

Cost-benefit of Biocontrol of Environmental Weeds

- Use just saved control costs – if known
- Mist flower – $80-90K/yr in 1998
- Biocontrol cost 1996-2001: $450K
- Even with underestimated control costs the benefit:cost ratio in 2015 was 2.5:1 (NPV)
- As previously mentioned, we have data showing only minor replacement weed issues

Mist Flower

(*Ageratina riparia*)

Cost-benefit of Biocontrol of Environmental Weeds

- What if little or no control being undertaken e.g. heather in and around TNP
- Control costs estimated for NZ Defence Force
- $1.05m/yr for 5 years – repeat period?
- Biocontrol costs were $2m 1990-2017
- Herbicides too expensive and too many harmful side effects on native flora
- Mechanical control favours heather!
- Biocontrol only remaining option

Positive Benefits of Weeds

- Also need to assess any positive benefits of weeds – e.g. broom and beekeepers
- Non-target effects – possible effects from damage to tagasaste (dry land fodder)
- Benefit to NZ was still $6m/yr if broom biocontrol was successful
- But what about ecosystem services (carbon, succession, water, erosion control?)

Source: Jarvis PJ et al. 2006. Predicting the economic benefits and costs of introducing new biological control agents for Scotch broom *Cytisus scoparius* into New Zealand. Biological Control 39, 135-146

Broom (*Cytisus scoparius*)

Another Promising Project – *Tradescantia fluminensis*

Tradescantia fluminensis

- Expensive – $2m over 10 years
- Diverse benefits and costs to challenging variety of sectors inc. vet costs for dogs
- Funding issues – probably core $$ esp. for such a “flagship” project
- Waikato DC – 18 ha bush reserve: herbicide would cost $125K over 10 years v. $24K for biocontrol releases

Source: Ben Wolf [Ben.Wolf@waidc.govt.nz]

Summary

- Analyses show very substantial benefits to NZ from biocontrol of weeds: similar B:C ratios as detailed Australian studies
- Some caveats e.g. replacement weeds
- No overall benefit:cost analysis done for all programmes
- Biodiversity/ecosystem service benefits remain challenging
- Research on-going

New Zealand's monument to biological control?

Thanks

Acknowledgments: All sources used. Grant Humphries (Otago Uni). Marie Fromont. Funding from the Science and Innovation Group in the Ministry for Business, Innovation and Employment (MBIE: contracts C09X0210, C09X0504, C0X0905) , Landcare research core funding from MBIE, and MPI Sustainable Farming Fund. Anyone I've missed.