

Modeling the Risks and Damages from a “Potential” Invasive Plant Species: Yellow Starthistle (*Centaurea solstitialis*)

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Mitacs Accelerate Program

- Funded by Mitacs Accelerate Program & the British Columbia Cattlemen's Association (BCCA)
- Partner and beneficiary: BCCA
- Deliverables include:
 - *Invasive damage estimates*
 - *Land mgmt recommendations*
 - *ENGO involvement*



Yellow Starthistle (YST) - A Dangerous Invader

■ Characteristics:

- *Long germination season*
- *High seed productivity (75-100k)*
- *Deep taproot*
- *Establishes and disperses best in human-disturbed areas*



Fig. 1 - Unpalatable to cattle

Known Effects

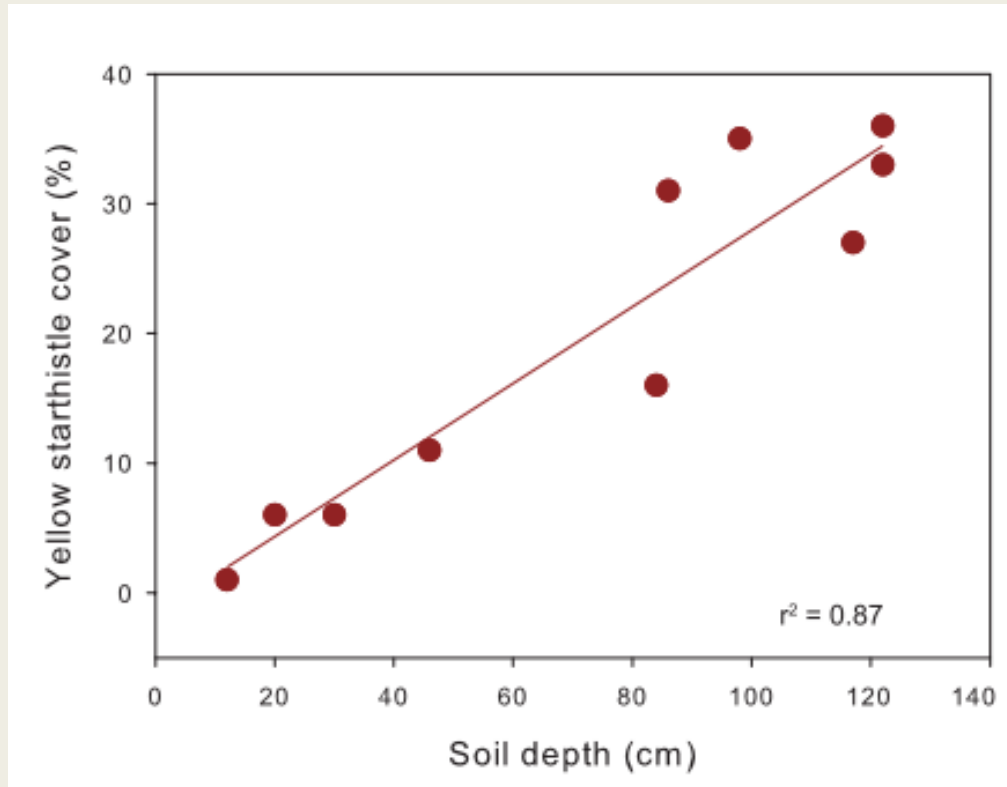
- Direct effects:
 - *Ranching*
(*unpalatable to cows*)
 - *food crops*
- Indirect effects:
 - *biodiversity loss*
 - *tourism & recreation*



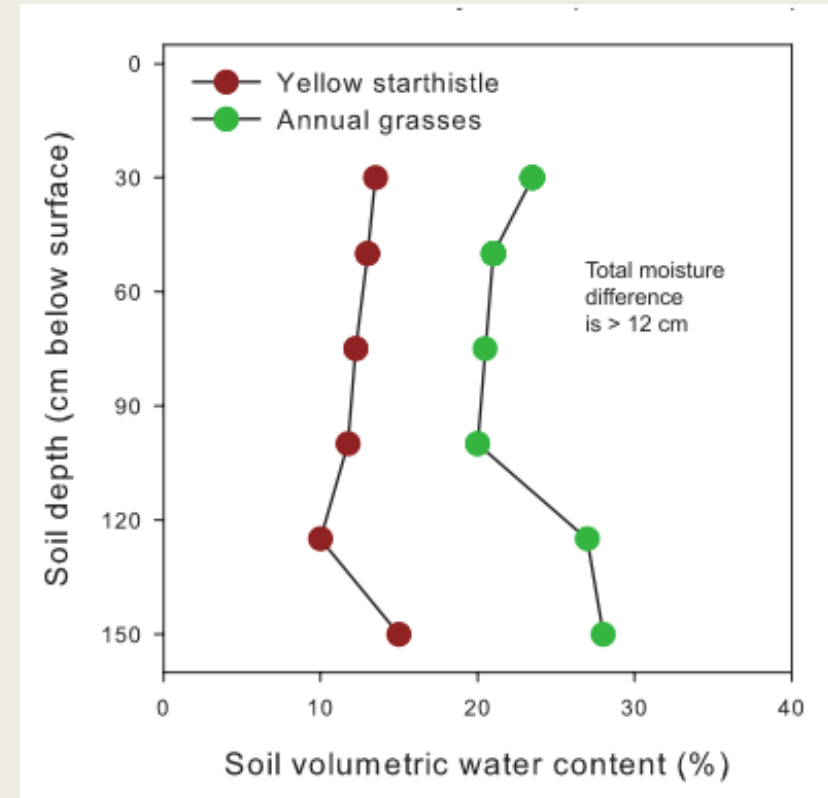
Fig. 2 - Dense Stands

Known Effects - Watersheds

- Significantly affects soil moisture content



Roche, 1994



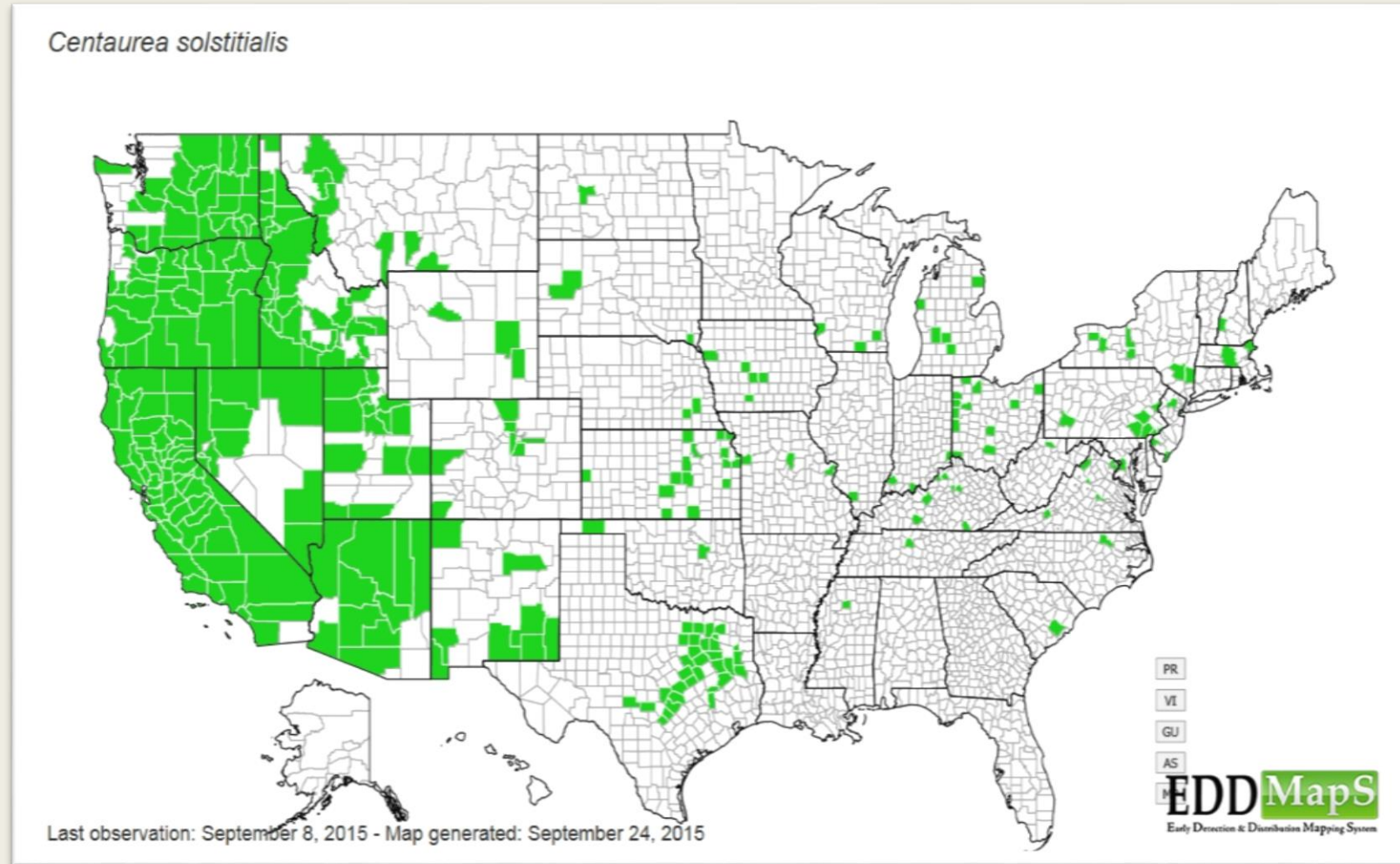
Gerlach, 2003



Risks for BC

- Well suited to Columbia Basin climate (Zouhar, 2002)
- Maximises its potential on blue bunch wheat grass and Idaho fescue (Ibid.)

YST dispersion in the USA



BC's Beef Cattle Industry

- Constitutes 5% of Canada's cattle population
- Mainly cow-calf operations
- Born and raised on rangeland
- \$600M/year industry
- 8700 persons employed
- Land-stewardship



Research Questions

- What are the optimal levels of cattle stocking/offtake on ranch grasslands?
- What would be the difference in returns with or without the invasion?
- How sensitive are ranch-level returns to: stocking levels, forage growth rate, beef prices, levels of YST invasion?
- How can the above results inform management practices and therefore prevention?

Model Overview

- Bioeconomic optimal control (dynamic optimisation) model
- Variables subject to control are cattle offtake (N) or stocking rate (H)
- Integrates risk via a hazard function (Barbier et al. 2011)¹
- Captures trade-off facing ranchers: whether to continue with current management or modify to reduce risk

¹ a hazard function is the probability something happens given it hasn't happened up till now

1st phase: Ranch level optimisation

- Basic ranch level profit maximization formulation
- Derive basic steady-state solutions for optimal stock size X^* and offtake N^*
- Compare both “no-invasion” and “with-invasion” scenarios

$$\max_N \int_0^T e^{-\delta t} (pN - (p_m N + p_a L + p_h X)) dt$$

$$s.t. \quad \dot{X} = rX \left(1 - \frac{X}{aL} \right) - N$$

w/out YST

$$\max_{N,D} \int_0^T e^{-\delta t} (pN - (p_m N + p_a L + p_h X + wD)) dt$$

$$s.t. \quad \dot{X} = rX \left(1 - \frac{X}{aL} \right) - N$$

$$\dot{U} = yU \left(1 - \frac{U}{U_M} \right) - T(D)$$

YST Present

2nd phase: Integrating YST Risk & Damages

- Use information about potential costs from YST invasion consisting of lost grazing and control costs
- Integrate a hazard function as in Reed & Heras (1992)
- Increases the risk and recognizes the potential shift to an invasion dominated system
- Highlights the trade off for ranchers: they can continue with current management but risk a shift to an invaded situation

More on Risk: Hazard function

- Determine invasion hazard risk as function of plant characteristics
- Baseline (average) hazard = 0.005
- Thus, probability of invasion by typical invader is 0.5%
- In contrast, YST hazard is 0.008 or 0.8%
- Due to YST having greater than average invasive characteristics

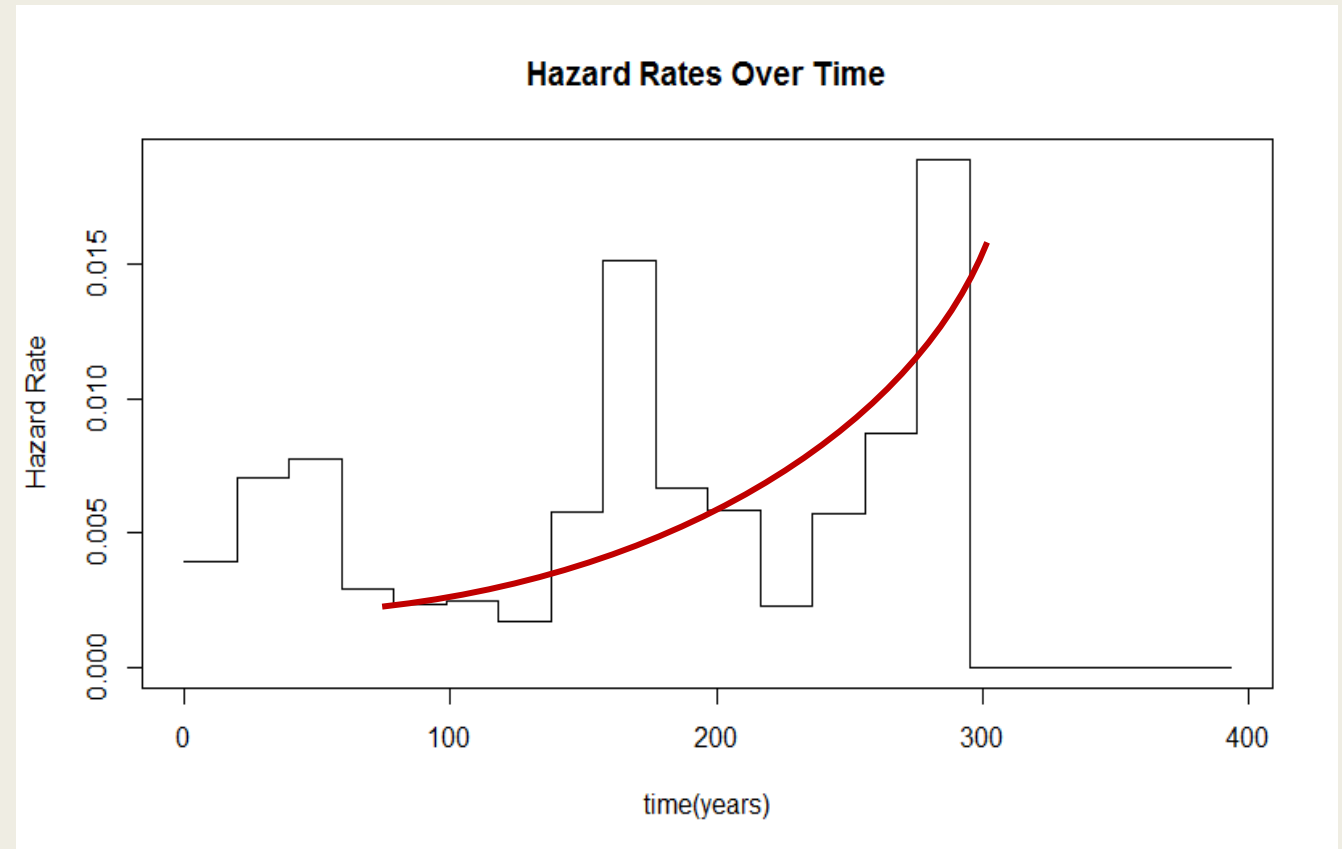


Fig. 3 – Cumulative Hazard function

3rd Phase: Managing for Potential Invasion

- But there is a tradeoff, e.g. lower stocking rates → lower profits.
- Formulate as a “decision problem” where rancher can continue with risk of YST invasion (as discussed above)
- Can assess if there is an optimal time to “switch” to modified management to reduce invasion risk

Significance & Policy Implications

- Will better inform policy-makers whether there is a need to establish targeted preventative programs
 - *“An ounce of prevention is worth a pound of cure.”*
(Finnoff, 2007)
- Can be updated as new data and research become available

Challenges & Limitation

- Under-representation of true damages (analysis from ranch profit-maximization perspective)
- Optimisation caveats (over-representing revenues and damages due to optimality conditions)
- Integrating the effects of climate change

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QUESTIONS & COMMENTS

Thank you

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