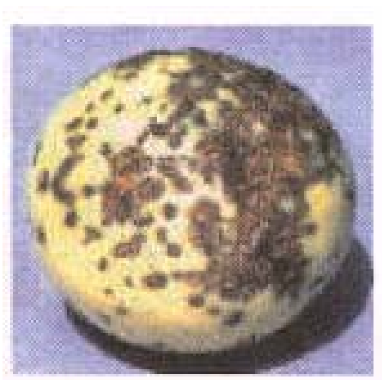
International Trade and the Economics of Invasive Species Prevention and Control

Imported Fire Ants



Citrus canker

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Research Overview

- Analyze the economics of prevention and control of invasive species introduced through trade
  - account for growth and spread of established invasions
  - dynamic benefit-cost analysis
- Characterize optimal policies for prevention and control in terms of economic and ecological primitives of the models:
  - appropriate balance between prevention and control
  - restrictive trade measures (ex: fruit fly pathways)
  - eradication of established invasions (ex: boll weevil)
  - maintenance control or management of an invasion at a positive level (ex: gypsy moth – Slow the Spread)
  - do nothing

Imported Goods

Provide benefits from consumption or as inputs to production

Spanish clementines/ Mediterranean fruit fly

Solid wood packing material/ Asian longhorn beetle

Potential pathways for invasive species introductions

3 options:

- Reduce introductions through trade
- Control established invasions
- Live with invasion damages

Trade policy can reduce or prevent invasive species introductions

U.S. Customs Agent APHIS beagle

Heat treatment of wood pallets

preclearance

Chile	Stonefruit (I or T) Lemons, Grapes (T) Kiwi, Lime (I or T) Lime, Cherimoya (T) Cut Flower (I)
I = inspect T = treatment	91 other commodities (I)

τ = measure of trade policy restrictions

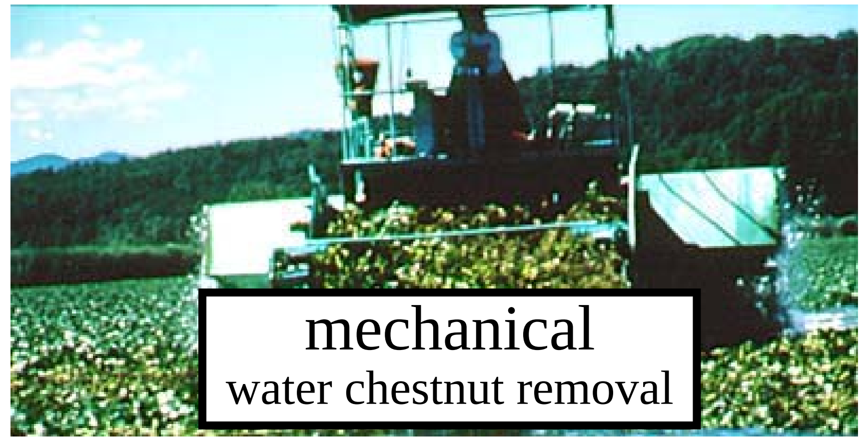
$i(\tau)$ = invasive species introductions when policy is τ

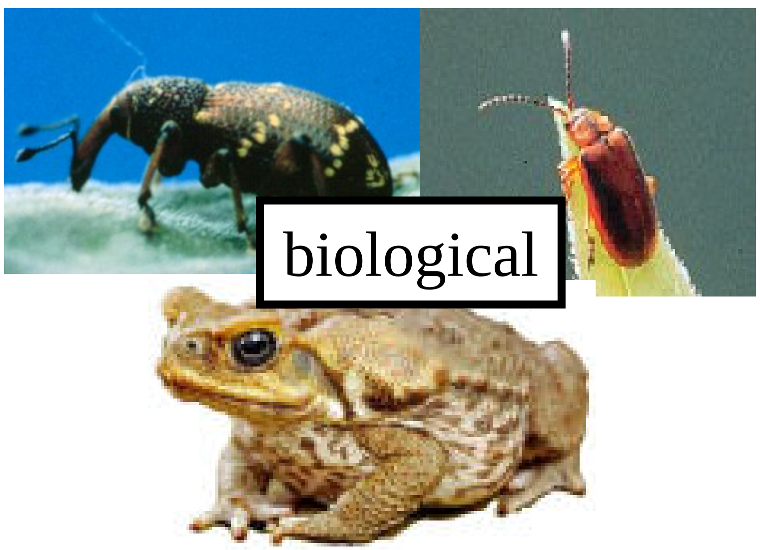
$W(\tau)$ = Consumer surplus from imports less welfare cost of trade policy

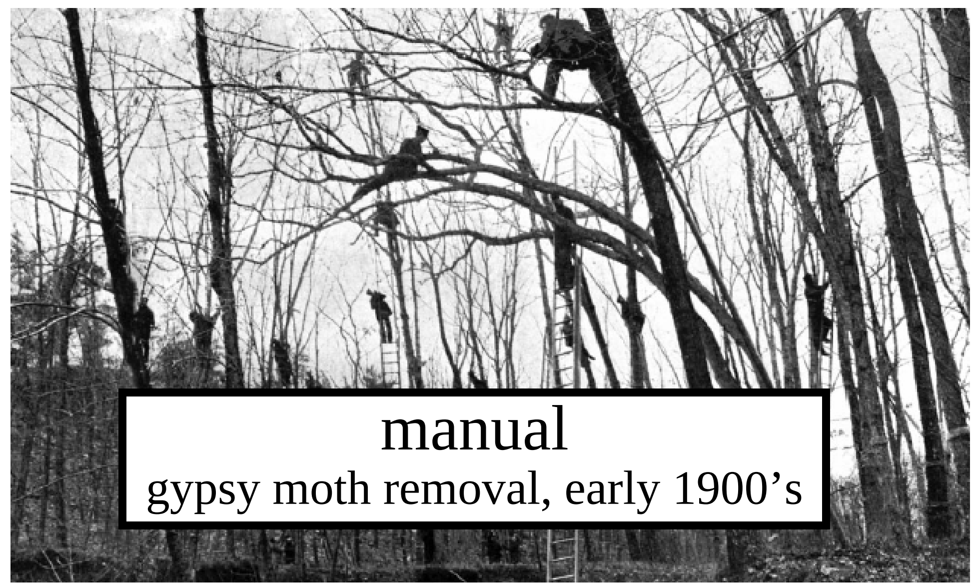
More stringent trade restrictions decrease introductions of invasives, but also lower welfare through reduced consumer surplus and increased program costs

$\bar{\tau}$ = prevention policy (no introduction)

a_t = control = reduction in size of invasion





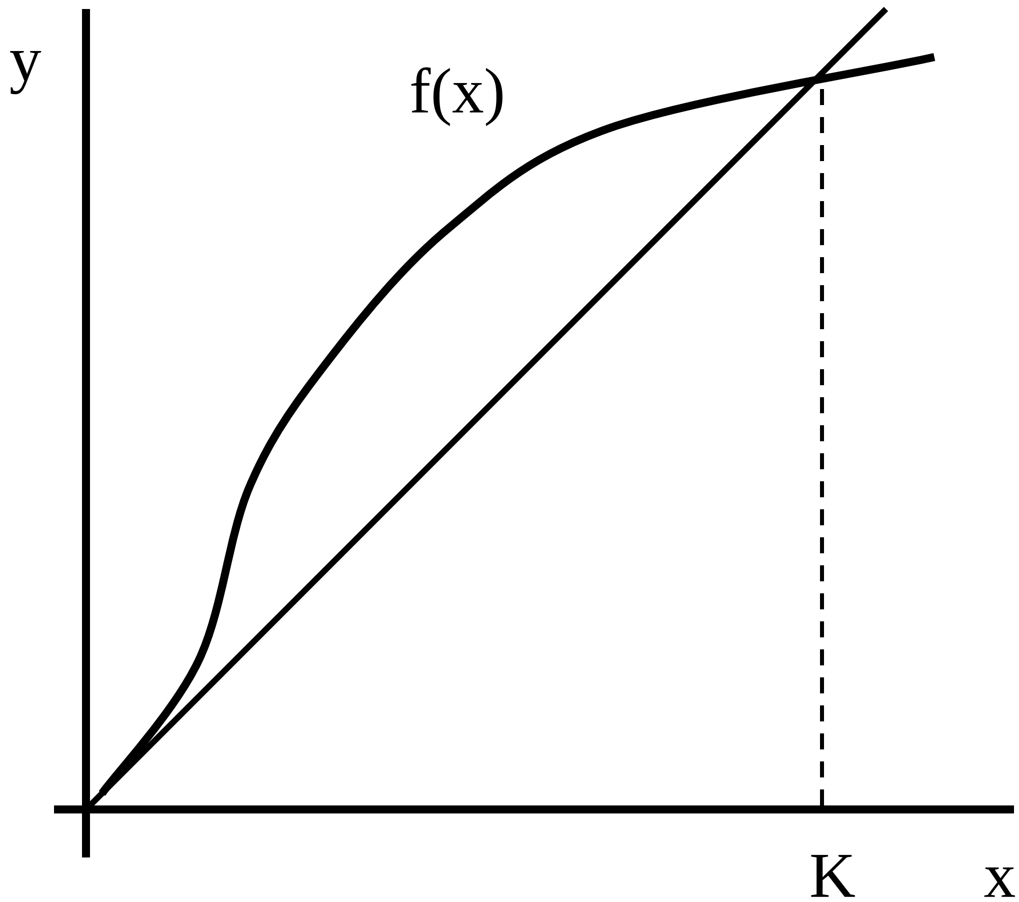


C(a) = min cost of reducing invasion of size y by a

Invasion growth: $y_{t+1} = f(x_t)$

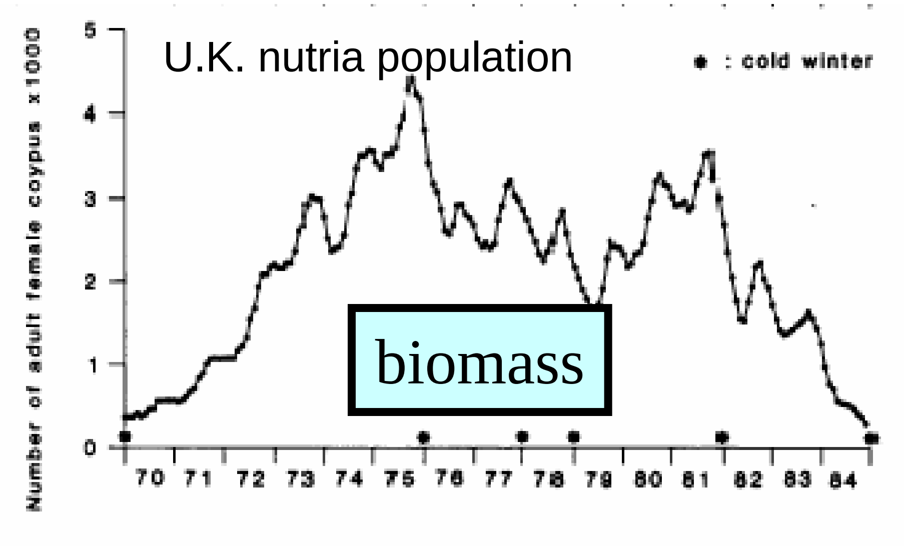
y_t = aggregate measure of invasion size

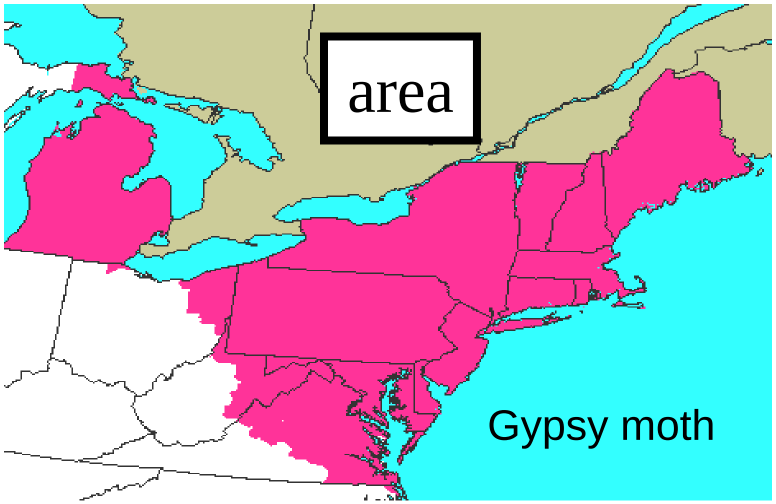
$x_t = y_t + i(\tau_t) - a_t$ = end of period invasion size

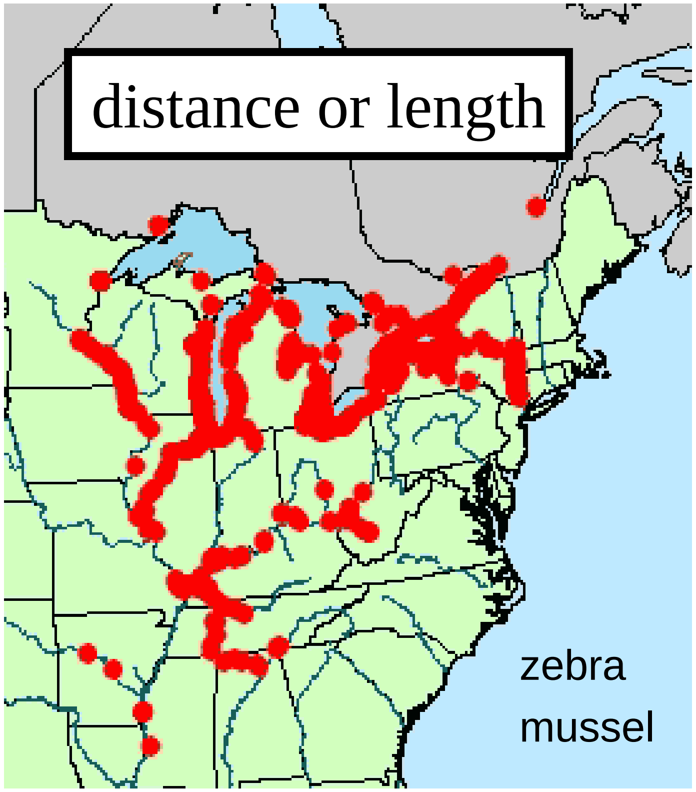


D(x_t) = invasion damages,

determined by end of period invasion size







Social Welfare

Social Welfare = $W(\tau) - C(y+i(\tau)-x) - D(x)$

= Welfare from Trade

minus Costs of Control

minus Economic Damages from Established Invasion

Objective: Choose trade and control policies to maximize the discounted sum of welfare over time subject to the transition equation that governs the growth and spread of an established invasion

Balancing Invasive Species Policy Alternatives

Choice among alternatives depends on their opportunity cost

$C_a(a)$ = cost of reducing a unit of invasive species through control

$W_\tau(\tau)/i_\tau(\tau)$ = cost per unit of invasive species prevented through trade restrictions

$$D_x(x_t) + \sum_{i=1}^{\infty} \delta^i D_x(x_{t+i}) \prod_{j=0}^{i-1} f_x(x_{t+j}) =$$ discounted stream of damages attributable to one more unit of invasive species today

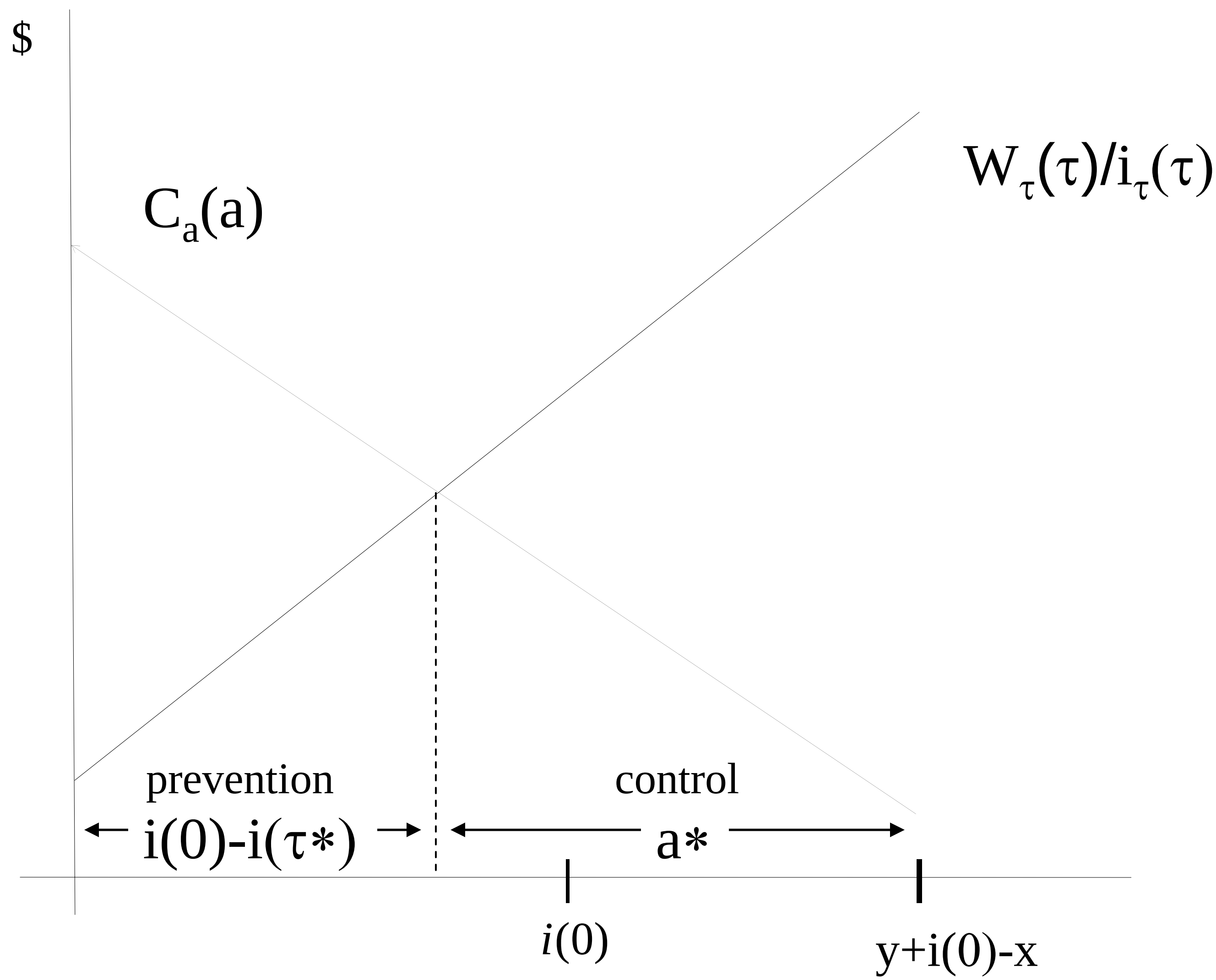
2 stage decision problem:

Starting point = established invasion size plus introductions through trade = $y+i(0)$

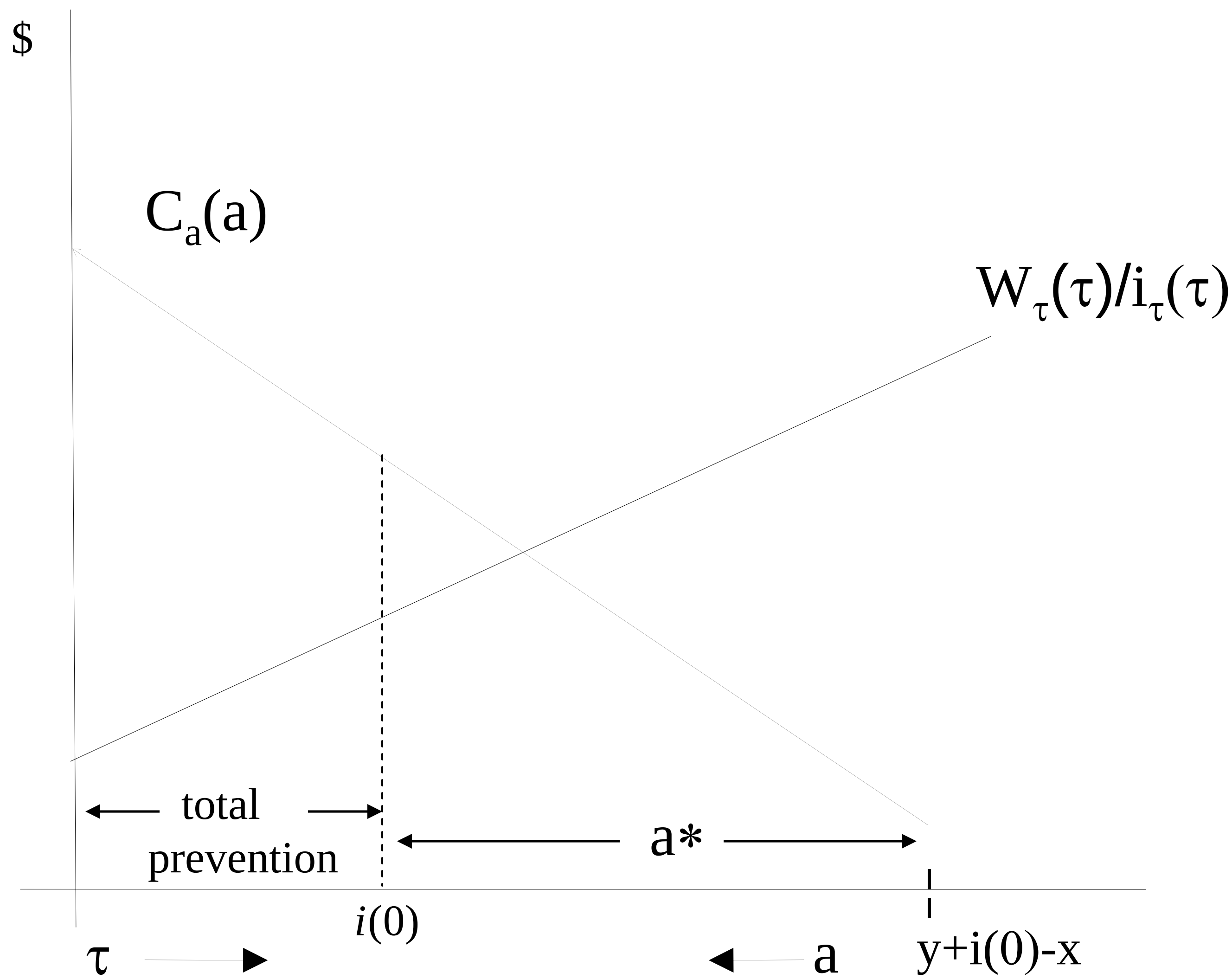
1) For each end of period invasion size, choose the mix of prevention and control that minimizes the cost of achieving x.

2) Determine the optimal invasion size by balancing the cost of achieving x against the invasion damages that result from x

Prevention vs. Control
Both policies used, some introductions occur

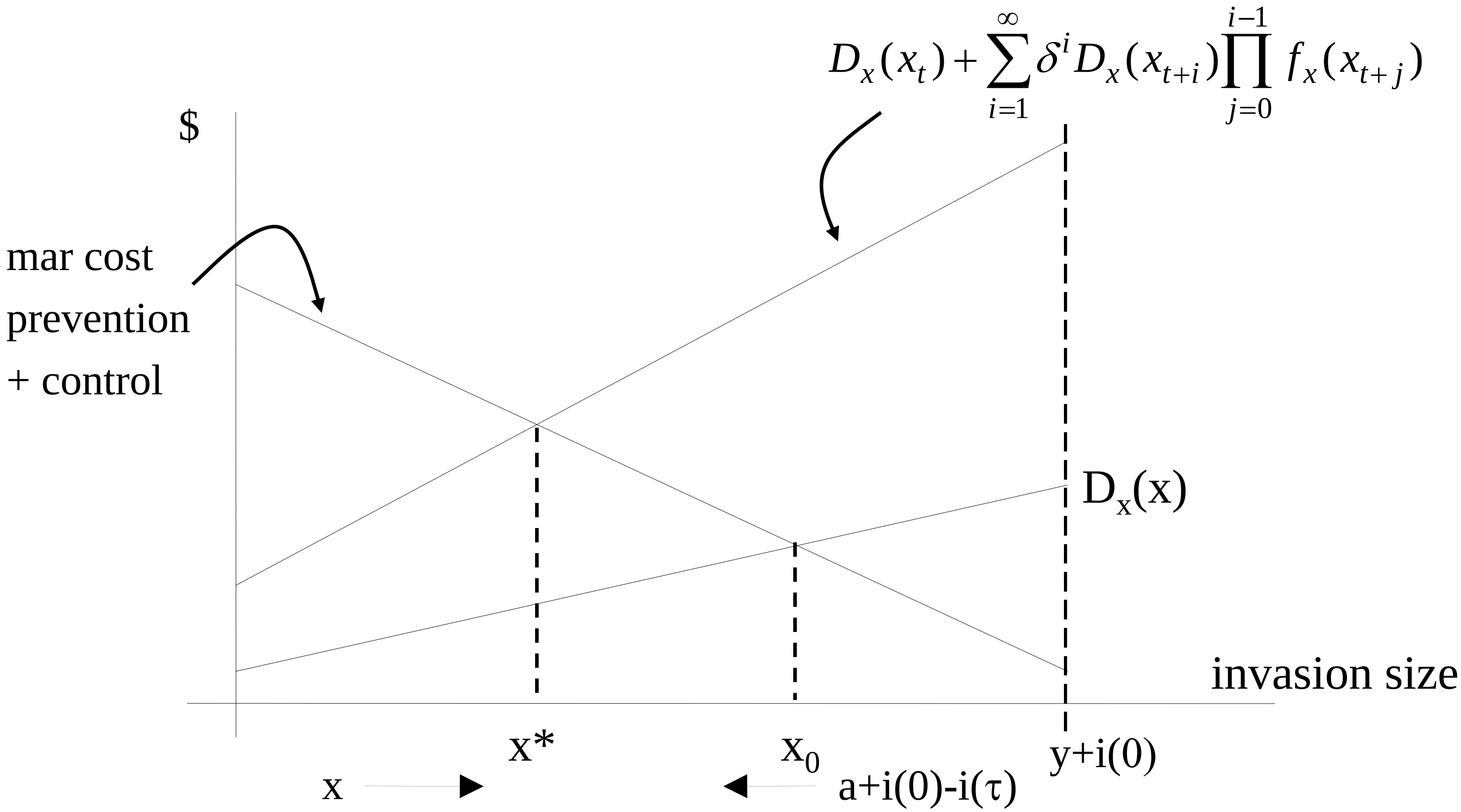


Prevention vs. Control
Trade policy prevents all introductions



Optimal management of invasion size

Mar cost of prevention and control $= D_x(x_t) + \sum_{i=1}^{\infty} \delta^i D_x(x_{t+i}) \prod_{j=0}^{i-1} f_x(x_{t+j})$



$$D_x(x_t) + \sum_{i=1}^{\infty} \delta^i D_x(x_{t+i}) \prod_{j=0}^{i-1} f_x(x_{t+j}) =$$ discounted stream of damages attributable to one more unit of invasive species today

2 effects of an increase in invasion size:

•marginal damages increase

•invasion growth rate changes

If the invasion growth rate falls faster than the increase in marginal damage then net social marginal damages may be decreasing in the invasion size. Even though current marginal damages are higher the consequences for future marginal damages may be less.

Policy implications: The optimal amount of prevention and control can decrease with the invasion size if the invasion growth rate slows enough to offset the increase in marginal damages

Prevention Policy

Factors favoring greater prevention

•high marginal costs of control

  -more control

•high marginal damages from invasion

  -larger invasion size

•greater rate of species introduction

•high invasion growth rate

•smaller marginal effect on consumer surplus from imported good

•greater marginal effect of prevention policy on introduction rate

Optimal prevention depends on invasion size and may vary over time

Control Policy

Factors favoring greater control

- low marginal costs of control
- high marginal damages from invasion
  - -larger invasion size
  - -greater rate of species introduction
- high invasion growth rate
- higher marginal cost of prevention
  - -greater marginal effect on consumer surplus from imported good
  - -small marginal effect of prevention policy on introduction rate

Optimal control depends on invasion size and may vary over time

- Optimal invasion size may depend on initial state
- Possibility of multiple optimal steady states
- Eradication may be optimal from small invasions but not from large invasions