Partnerships Across Spatial Scales

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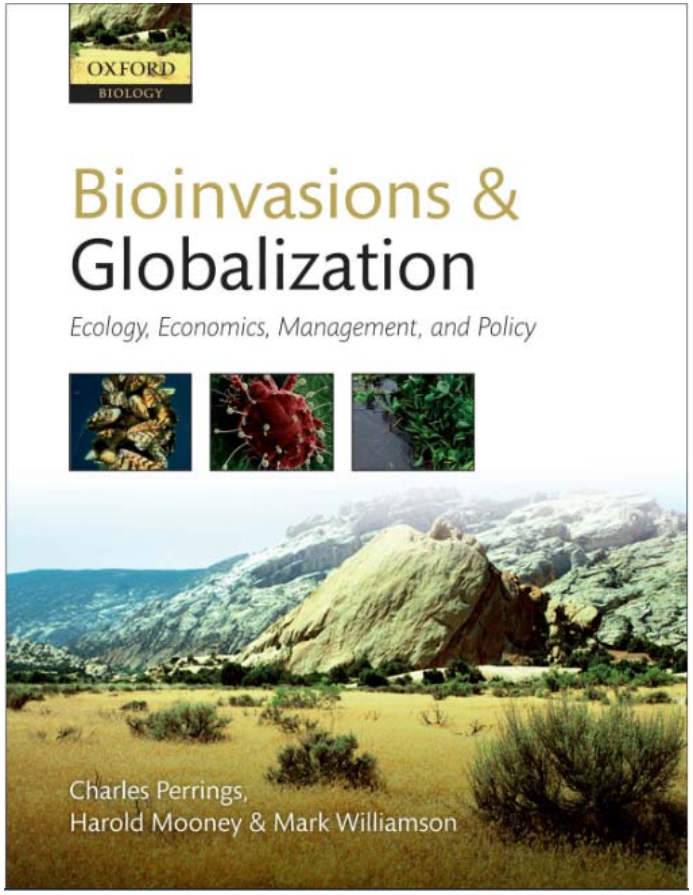
Strategic management of invasive species in the southwest United States
BLM National Training Center, October 26-30, 2009, Phoenix, AZ

- Charles Perrings, Harold Mooney and Mark Williamson (eds) 2009. Bioinvasions and Globalization: Ecology, Economics, Management and Policy, Oxford, Oxford University press (in press)

- Cover picture of Cheat grass (*Bromus tectorum*) infestation in Dinosaur National Monument, UT-CO (the photo was taken in Utah by John Randall of The Nature Conservancy in 2006).

- Sonoran desert: 380 introduced species estimated to cover approximately 1,400,000 acres (Phillips and Comus 2000).



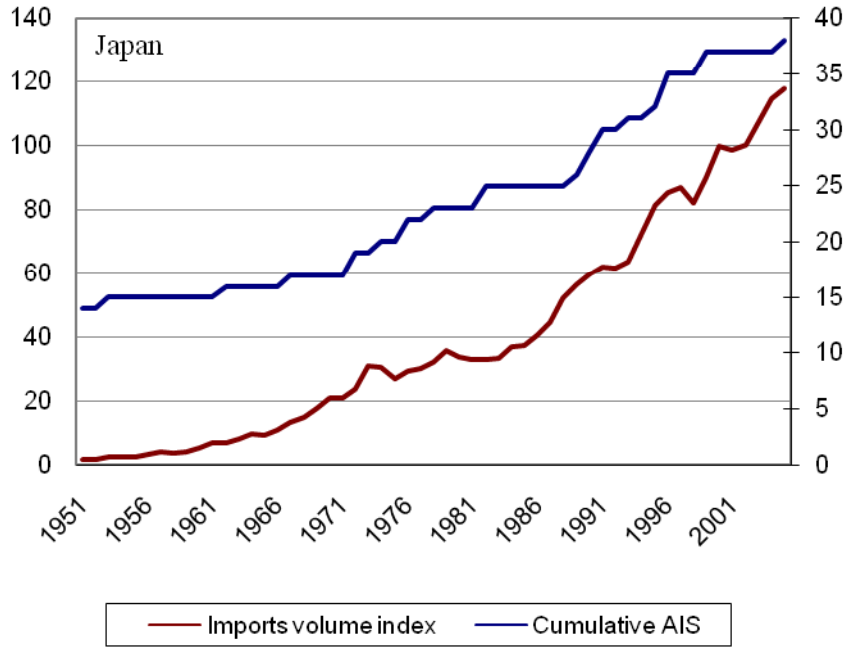
Phillips S.J. and P. W. Comus. 2000. A Natural History of the Sonoran Desert. Arizona-Sonora Desert Museum Press: Tucson.

The risks of invasive species increase with...

- the integration of the world economy (the increasing volume of trade, aid, transport and travel);
- the invasiveness of the species (a property of species traits, including plasticity);
- the vulnerability of the host system to invasion (as a result of disturbance, including fragmentation and species loss);
- the bioclimatic similarity and geographical distance between source and host countries.

Invasive species and trade volumes are positively correlated

- Species introductions increase with trade volumes
- Every container of imports and every passenger contains a sample of the organisms in the country of exports
- Increase in the speed of trade increases the likelihood of their survival



WTO International Trade Statistics.

Estimates of the costs of invasive species

USD (2000) billion pa

We lack good estimates of the cost of invasive species. In 2001 Pimentel et al estimated US costs at around USD 60bn per annum.

Introduced pest	United States	United Kingdom	Australia	South Africa	India	Brazil	Total
Plants	0.148	–	–	0.095	–	–	0.178
Mammals							
Rats	19.000	4.100	1.200	2.700	25.000	4.400	56.400
Other	18.106	1.200	4.655	–	–	–	23.961
Birds	1.100	0.270	–	–	–	–	1.370
Reptiles/Amph.	0.006	–	–	–	–	–	0.006
Fishes	1.000	–	–	–	–	–	1.000
Arthropods	2.137	–	0.228	–	–	–	2.365
Mollusks	1.305	–	–	–	–	–	1.305
Livestock Diseases	9.000	–	0.249	0.100	–	–	9.349
Human Diseases	6.500	1.000	0.534	0.118	–	2.333	10.467
Total	58.299	6.570	6.866	3.013	25.000	6.733	106.481

Source: Pimentel et al (2001)

Pimentel, David, S. McNair, S. Janecka, J. Wightman, C. Simmonds, C. O'Connell, E. Wong, L. Russel, J. Zern, T. Aquino and T. Tsomondo, 2001, Economic and environmental threats of alien plant, animal and microbe invasions, *Agriculture, Ecosystems and Environment* 84:1-20.

Environmental costs not normally taken into account in estimating the cost of invasive species

- Indirect impacts on ecosystems through effects on other species
  - Impairment of ecosystem functioning through loss of functional diversity – affecting sensitivity to variation in precipitation or temperature
  - Impact on hydrological flows and soil erosion through changes in vegetation cover
  - Impact on fire regimes through changes in fuel load and fuel characteristics

- Long term impacts
  - Associated with the irreversibility (or at least hysteresis) associated with many changes
  - Associated with the evolution of the new system - hybridization, perhaps coupled with polyploidy, can result in new potentially even more aggressive species

Estimates of the costs of invasive species

- USDA currently estimates that there are around 50,000 invasive species established in the U.S.

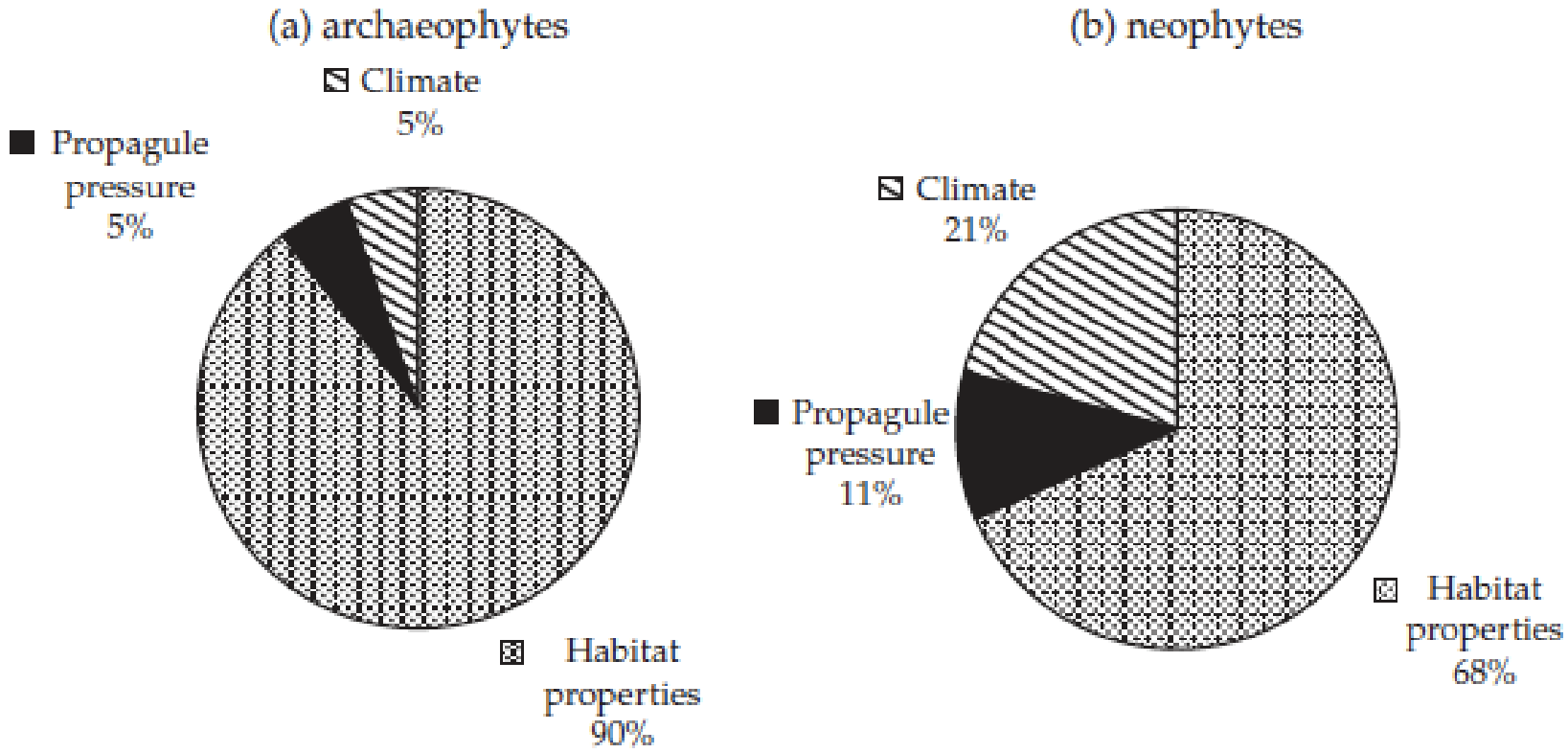
- Total costs around $138 billion annually including:
  - Damage costs, such as lost agricultural production
  - Control and management costs
  - Monetary losses from decreased tourism and recreational revenues

  but excluding:
  - environmental losses, such as a decline in biodiversity
  - human costs including pain and suffering inflicted by conditions such as allergic reactions to an invasive plant, or injuries from bites of fire ants

http://alic.arid.arizona.edu/invasive/sub7/index.shtml

The risk factors differ for old and new invaders

- The relative importance of drivers (land-use, climate and propagule pressure) is different for archeophytes and neophytes in Europe



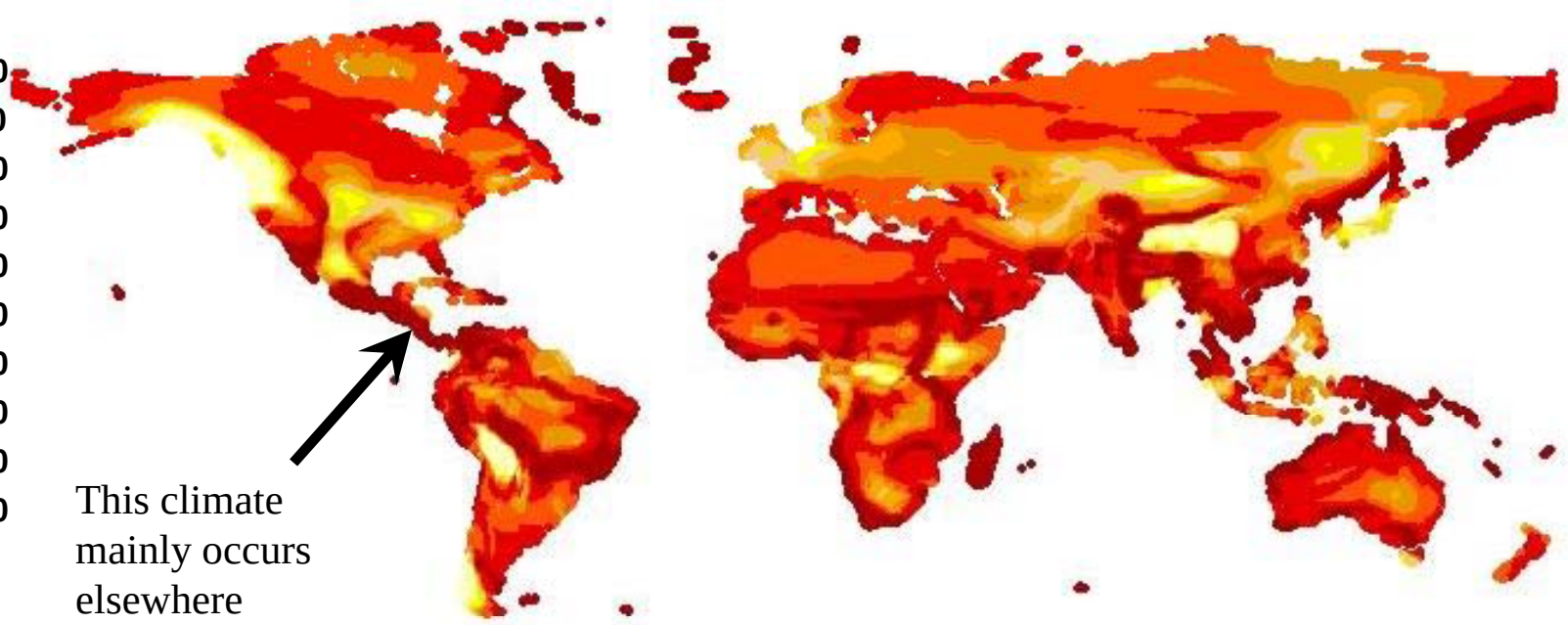
Pyšek, P. M. Chytrý, and V. Jarošík 2009 Habitats and Land Use as Determinants of Plant Invasions in the Temperate Zone of Europe In Perrings C., H. Mooney and M.Williamson. 2009. *Bioinvasions and Globalization: Ecology, Economics, Management and Policy*, Oxford, Oxford University Press: 66-79.

Climate change is expected to increase the invasibility of many systems

Climatic index of invasibility 1945

Proportion of climate within 1000km

- 0.00 - 0.10
- 0.11 - 0.20
- 0.21 - 0.30
- 0.31 - 0.40
- 0.41 - 0.50
- 0.51 - 0.60
- 0.61 - 0.70
- 0.71 - 0.80
- 0.81 - 0.90
- 0.91 - 1.00



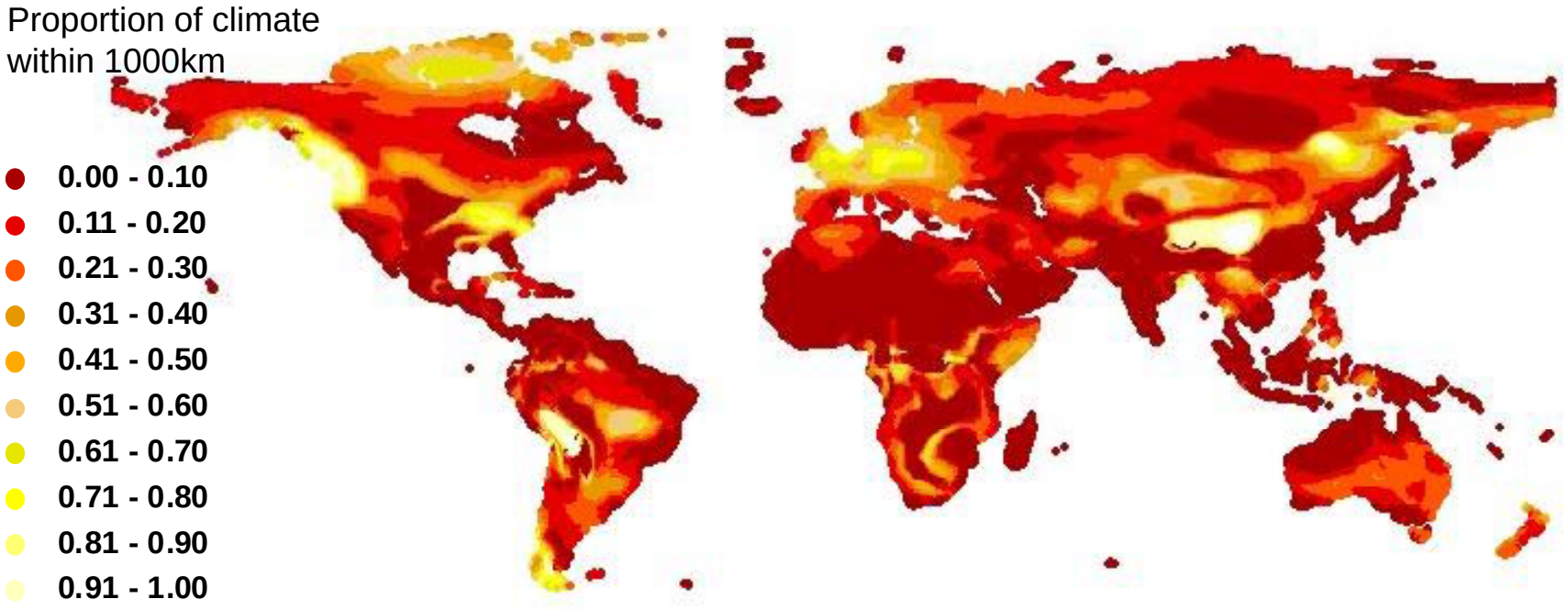
most climates of this type occurred < 1000 km away: RESISTANT

most climates of this type occurred > 1000 km away: INVASIBLE

Thomas C. and R. Ohlemüller 2009. Climate change and species' distributions: an alien future? In Perrings C., H. Mooney and M. Williamson. Eds. *Bioinvasions and Globalization: Ecology, Economics, Management and Policy*, Oxford, Oxford University Press.

Climate change is expected to increase the invasibility of many systems

Potential invasion index 2045 (HadCM3, B1)



most climates of this type (in 2045) occurred < 1000 km away in 1945

most climates of this type (in 2045) occurred > 1000 km away in 1945

Thomas C. and R. Ohlemüller (2008) Climate change and species' distributions: an alien future? In Perrings C., H. Mooney and M. Williamson. Eds. *Bioinvasions and Globalization: Ecology, Economics, Management and Policy*, Oxford, Oxford University Press.

Dividing up the management problem

- The key dimensions of the management problem are the control of
  - propagule pressure (introductions),
  - invasiveness (spread) and
  - host vulnerability (land use/disturbance)

- The actors in each case include both state and federal agencies and private interests. ‘Partnerships’ need to accommodate this.

- ‘Partnership’ options
  - informed voluntary association leading to cooperative or coordinated action
  - coordinated action induced by the use of incentive systems
    - charges for damages imposed on others (includes legal liability)
    - payments for IS prevention and control

The concept of externality

- Externalities (of land use) are effects of peoples' land-use decisions, that are not reflected in the market costs and benefits of those decisions, and so not taken into account by the decision-makers

- External benefits of land-management may include:
  - Enhanced capacity to resist invasive species
  - Reduced risk of spread of invasive species

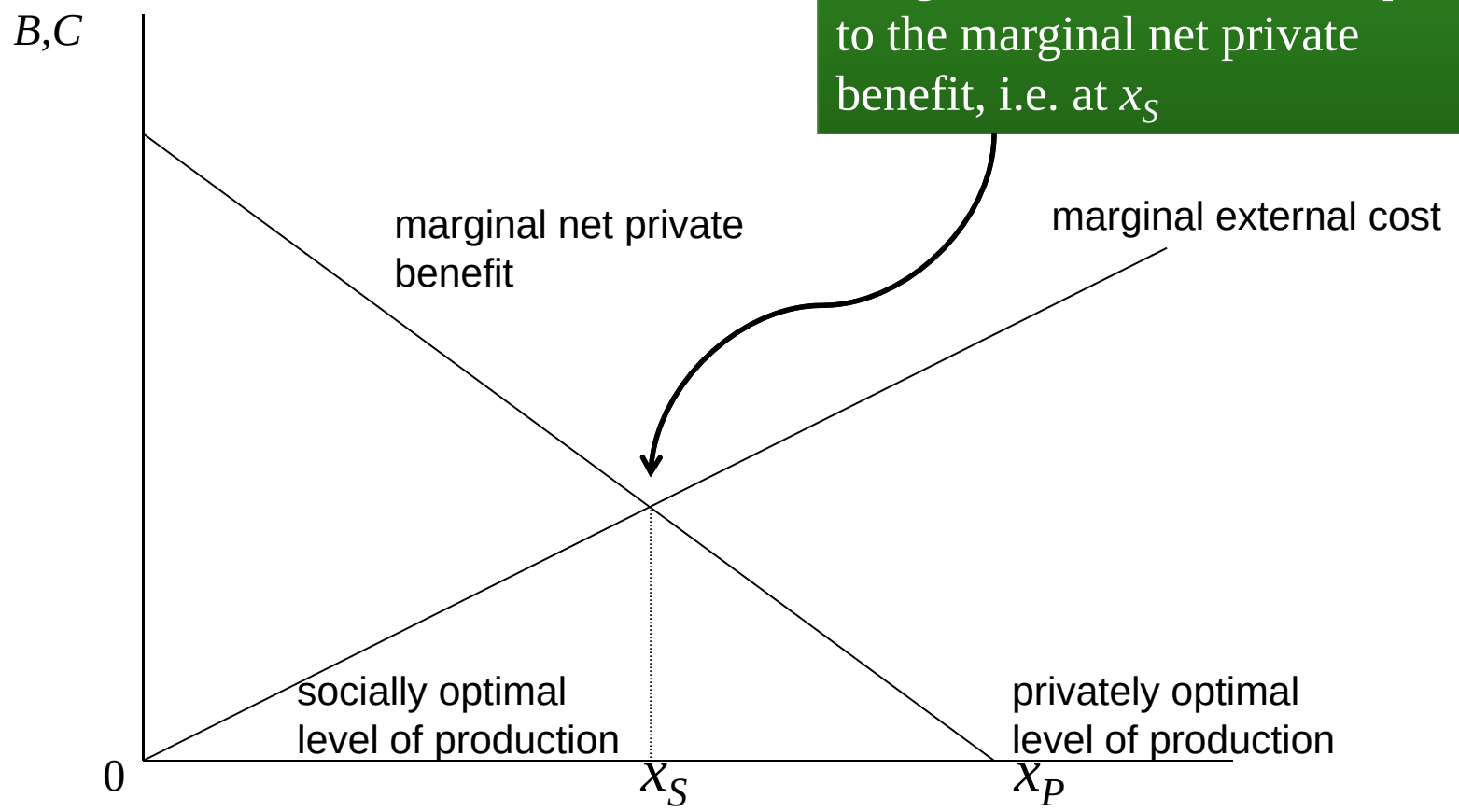
- External costs may include:
  - Reduced capacity to resist invasive species
  - Increased risk of spread of invasive species
  - Increased risk of associated damages (e.g. increased risk of fire, reduced water flows)

Externality and property rights

- Externalities indicate the absence of well-defined property rights implying that markets cannot be established for external environmental effects.
- Well defined property rights provide the owner of the rights with an incentive to manage the resource in a socially efficient.
- Internalizing invasive species externalities implies that land-holders should be confronted with the costs of their actions

Optimal externality

The optimal level of the externality is that at which the marginal external cost is equal to the marginal net private benefit, i.e. at x_S



Property rights in the solution to externality

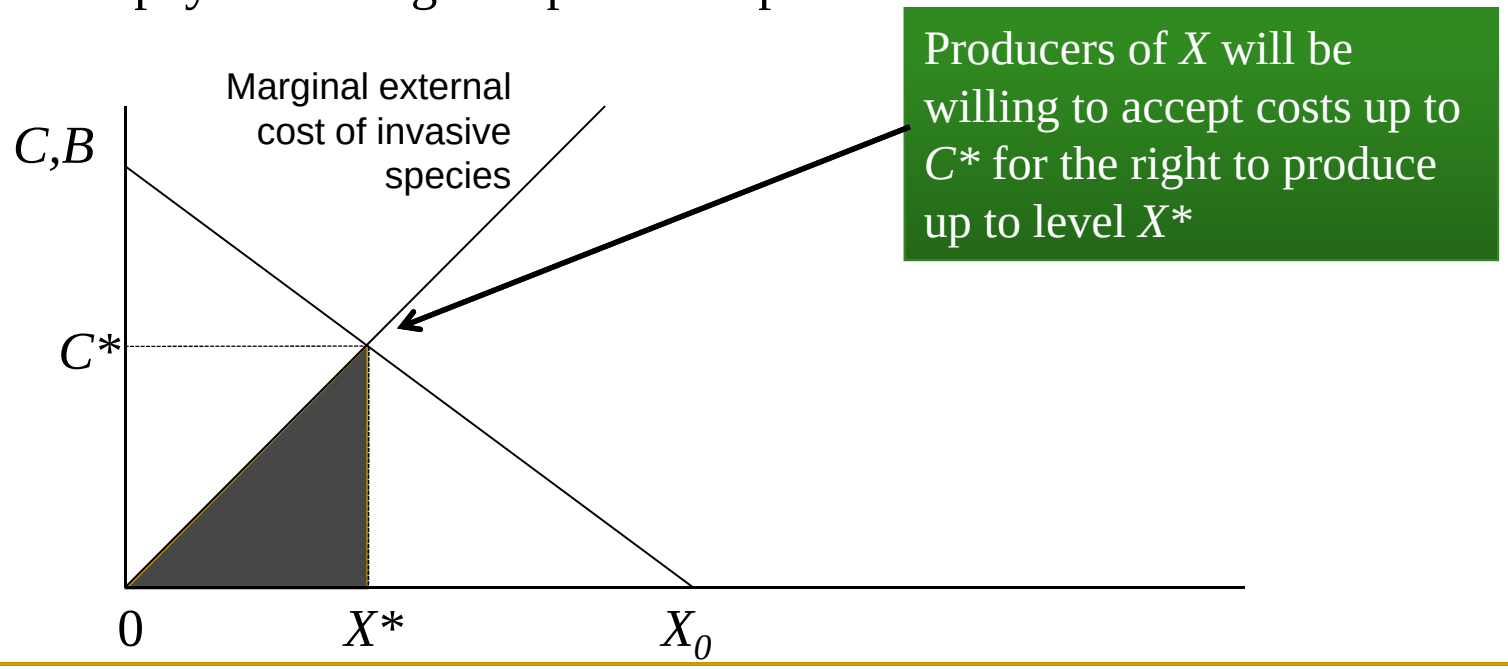
- The Coase 'Theorem' states that *if there are well-defined property rights in some environmental effect, if there are no transaction costs and if wealth effects are negligible, then the outcome of bargaining between the interested parties will be Pareto optimal regardless of the distribution of those rights.*

- Translated, it means that in certain circumstances it is possible to internalize external effects by assigning rights to the effect, and that the outcome will be efficient regardless of who receives the rights.

Property rights: the Coase theorem

- Suppose the spread of an invasive plant species from an area producing *X* leads to increased fire risk – and associated damage – in an area producing *Y*, and that the spread of invasives increases with production of *X*

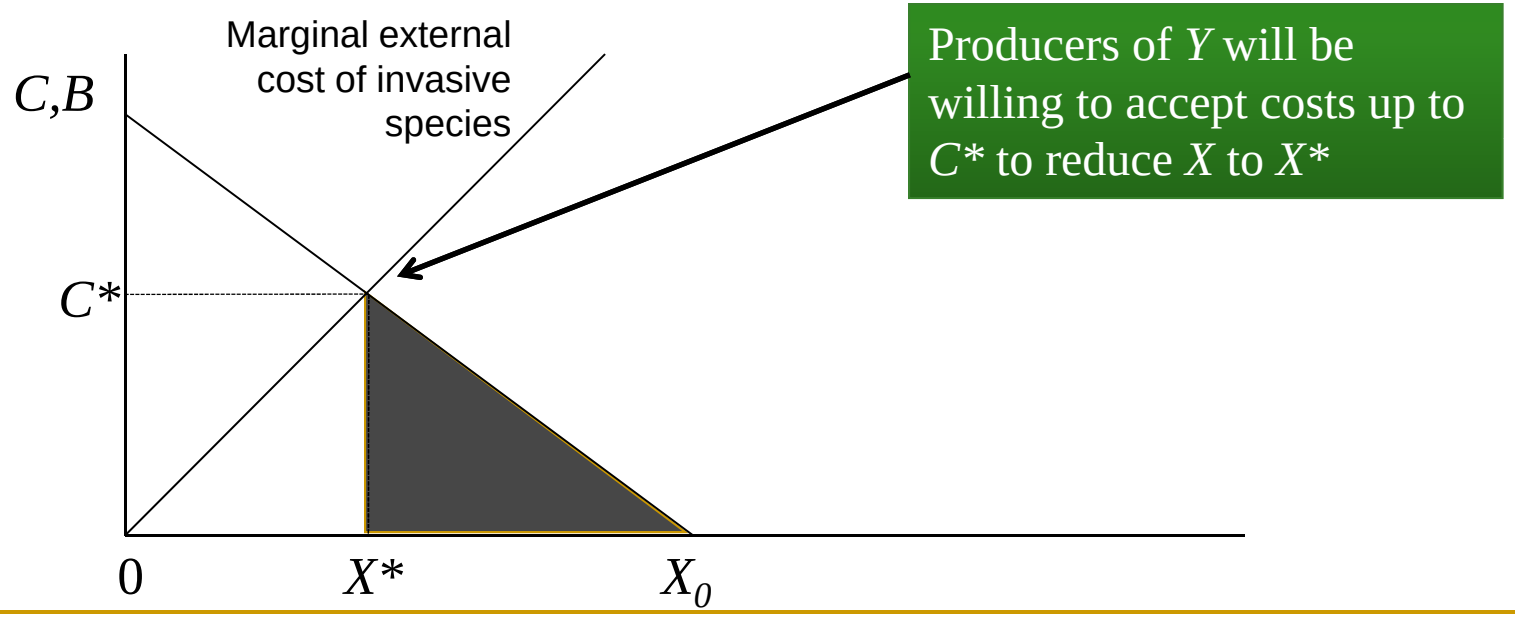
- If the producers of *Y* have the right to be free of invasives, the producers of *X* will pay for the right to produce up to *X**



Property rights: the Coase theorem

- Suppose the spread of an invasive plant species from an area producing *X* leads to increased fire risk – and associated damage – in an area producing *Y*, and that the spread of invasives increases with production of *X*

- If the producers of *X* have the right to allow the spread of invasives on their land, the producers of *Y* will pay for the right to curtail *X* to *X**



Investing in the environmental infrastructure

- Investment is needed to maintain critical environmental infrastructure (life support systems)
  - Example: Freshwater provision is likely to be a key constraint on growth in arid and semi-arid regions. It is highly sensitive to vegetation cover, and this is driving environmental investment in other parts of the world (e.g. 'Working for water', South Africa)

- Investment is needed for ecosystem restoration to reverse or compensate for changes that have impaired ecosystem functioning and the flow of ecosystem services such as
  - Habitat disturbance and fragmentation
  - Introduction of invasive species
  - Loss of diversity within key functional groups

An example from South Africa

- Invasive plants in the Sonderend catchment are estimated to have reduced river flows by 7% and have the potential, if uncontrolled, to reduce the flow by more than 40%.

- Pines account for more than half the volume of water, *A. mearnsii* a further 20%, eucalypts 12% and *Hakea* species 6%.

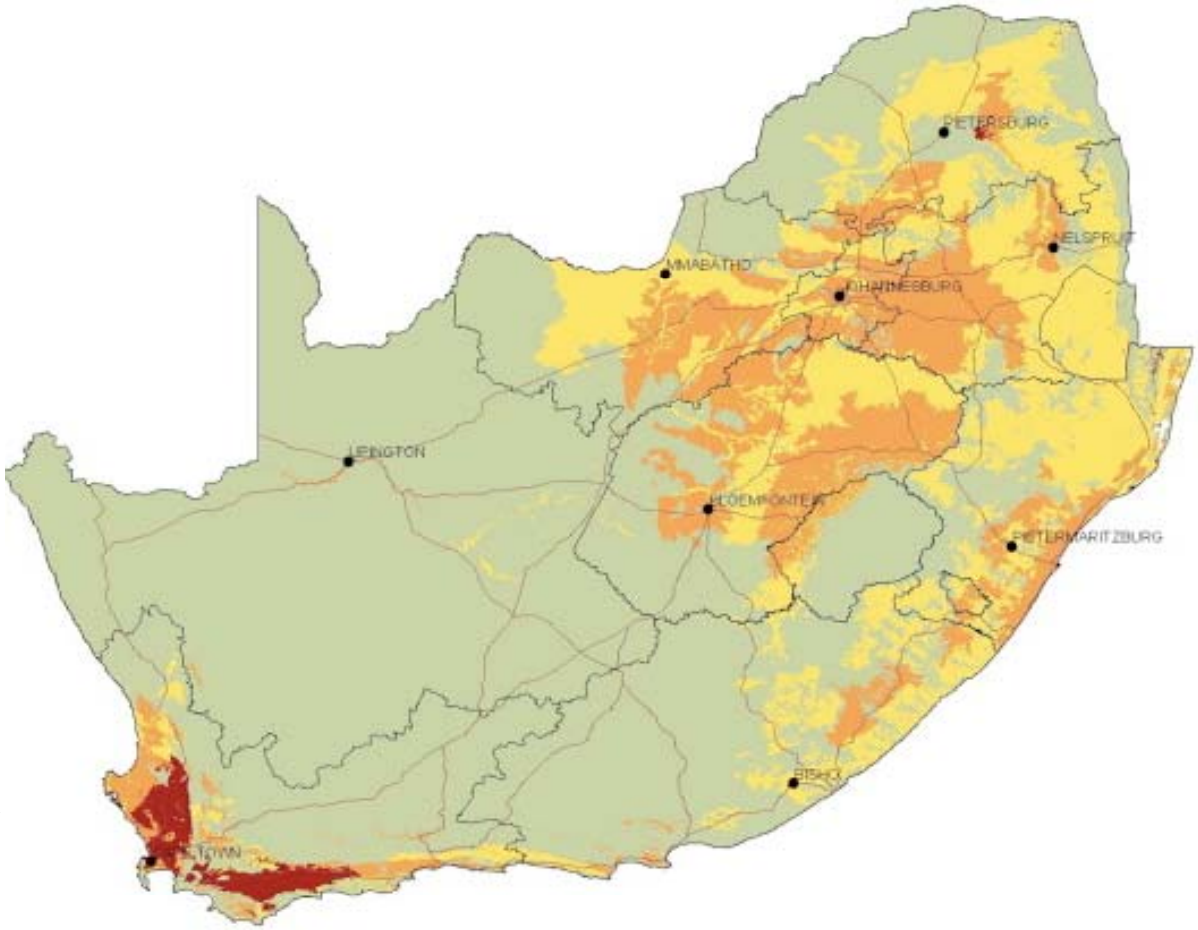
- At the current levels of infestation the costs of clearing the invaded area would be US$ 13 million or US$ 738/ha for the equivalent dense stands.

- Long-term maintenance after the initial programme is completed would cost about US$ 0.4 million per year. The cost of the control programme would increase more than 6.5-fold over the next 11–16 years if no action was taken. The highest priority will be given to clearing the invaded riparian areas, starting with the most upstream invaders.

Le Maitre, D.C. B.W. Van Wilgen, CM … - Forest Ecology and Management, 2002. Invasive alien trees and water resources in South Africa: case studies of the costs and benefits of management *Forest Ecology and Management* 160: 143-159.

An example from South Africa

- An invasive species control program that focuses on benefits in terms of water yields.



Critically endangered, endangered and vulnerable ecosystems in South Africa

Turpie, J., C, Marais and J.M. Blignaut 2008. The working for water programme: Evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa, *Ecological Economics* 65(4): 788-798.

Working for water, South Africa….

- Working for Water (WfW) program, launched in 1995 and administered through the Department of Water Affairs and Forestry.

- This program works in partnership with local communities, to whom it provides jobs, and also with Government departments including the Departments of Environmental Affairs and Tourism, Agriculture, and Trade and Industry, provincial departments of agriculture, conservation and environment, research foundations and private companies.

- Since inception, the program has cleared more than one million hectares of invasive alien plants providing jobs and training to approximately 20 000 people from among the most marginalized sectors of society per annum (52% women).

Working for water, South Africa….

- WfW currently runs over 300 projects using a range of methods to control invasive alien plants.
  - Mechanical methods - felling, removing or burning invading alien plants.
  - Chemical methods - using environmentally safe herbicides.
  - Biological control - using species-specific insects and diseases from the alien plant's country of origin. To date 76 bio-control agents have been released in South Africa against 40 weed species.
  - Integrated control - combinations of the above three approaches.

Working for water, South Africa….

- Associated initiatives include:
  - Legal responsibility for fire risks to neighboring properties
  - Legal responsibility for keeping land clear of invasive species
- As the hydrological benefits of WfW have become apparent, water utilities and municipalities have begun to contract WfW to restore catchments that affect their water supplies.
- This emerging PES system differs from others in that the service providers are previously unemployed individuals that tender for contracts to restore public or private lands, rather than the landowners themselves.

Turpie, J., C, Marais and J.M. Blignaut 2008. The working for water programme: Evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa, *Ecological Economics* 65(4): 788-798.

Implications for the US

- There is scope for using market mechanisms and market incentives to induce land-holders to take account of the risks that their actions impose on others.
- If there are benefits to be had from transactions between landowners, then it may be possible to encourage emergence of markets in IS control.
- Legal liability for the spread of invasive species from either private or state lands could have a similar effect.