Policy Instruments for the Provision of Environmental Services in Agriculture: Modeling Space and Biophysical Processes

Brown Bag Seminar, November 6th 2007

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Outline

- Overview of agri-environmental programs
- Diffusive processes and incentive design
- Using numerical simulation and analytical models to understand diffusion

Agri-environmental programs in the U.S.

- 1930s retirement programs for erosion control and commodity price support

- 1985 Conservation Reserve Program (CRP)
  - $1.8 billion yearly, 35 million acres enrolled
  - Auction based using an Environmental Benefit Index (EBI), on eligible areas

Agri-environmental programs in the U.S.: working land programs

- 1997 Environmental Quality Incentive Program (EQIP)
  - $885 million
  - Cost share for conservation projects
  - Auction option removed (2004), fixed pre-defined share by practice
- 2004 Conservation Security Progam (CSP)
  - $98 million
  - Stewardship payment based on practices on part or entire operation (Tier I, II, III) and fixed enhancement payments for additional practices
  - Fixed payment in eligible watersheds (331)
- 2007 Farm Bill
  - Consolidating programs
  - Continue funding

Agri-environmental programs in the E.U.

- Regulation 2078/92 of the Common Agricultural Policy (CAP)
- CAP budget €38 billions from which about €4 billions for agri-environmental schemes.
- Multifunctionality

- U.K. Environmental Stewardship:
  - Entry Level Scheme (non-competitive £30 per hectare per year, 5 years)
  - Higher Level Scheme (targeted areas, payment depends on options, 10 years)
- France : Grassland premium

Agri-environmental programs in the Australia

- National Action Plan for Salinity and Water Quality, including National Market Based Incentives (MBI) Pilots Program
- 57 Regional programs
- Leaders in auctions pilots:
  - Bush Tender Trial in Victoria
  - NSW Environmental Services Scheme

Challenges for current agri-environmental programs

- Multiple jointly determined environmental services (sometimes conflicting)
- Heterogeneity and information asymmetry
- Diffusion and externalities across farms

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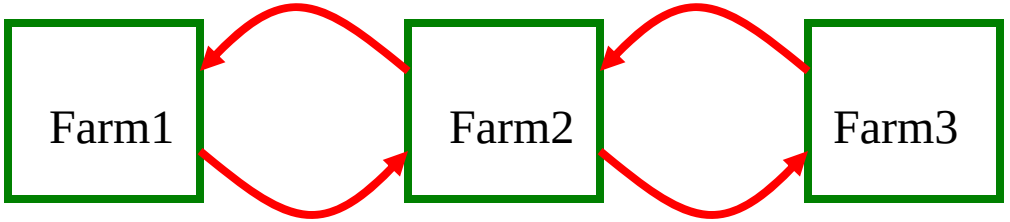
Research questions

- When do we need to take into account the connections between farms when designing conservation incentives?

- How well do we need to understand and model the biophysical processes involved in diffusion?

A simple model of wildlife diffusion and conservation

	Farm1	Farm2	Farm3
Carrying Capacity	$K_1 = f(effort_1)$	$K_2 = f(effort_2)$	$K_3 = f(effort_3)$
Opportunity Cost	$c_1 = h(effort_1)$	$c_2 = h(effort_2)$	$c_3 = h(effort_3)$



Equating marginal benefit of effort across farms may not be optimal with diffusion.

Wildlife diffusion and conservation

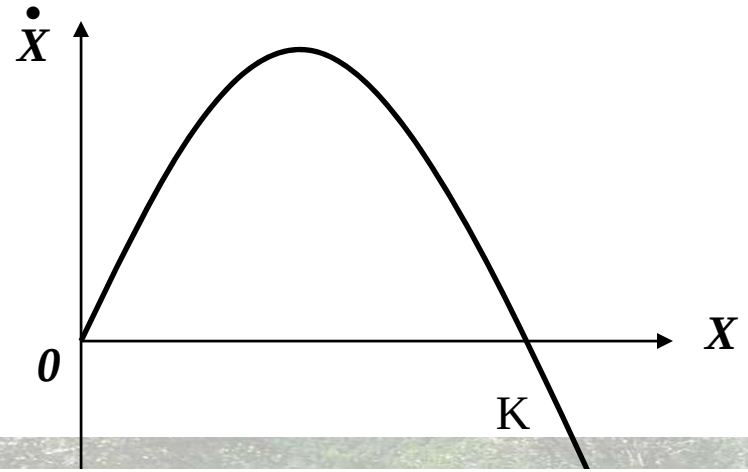
Equation of motion: logistic growth and diffusion

$$\frac{\partial X_i}{\partial t} = \sum_{j=1}^{n} d_{ij} X_j + X_i f_i(X_i)$$

$$f_i(X_i) = \alpha\left(1 - \frac{X_i}{K_i}\right)$$

$$\gamma\left[\frac{X_j}{K_j} - \frac{Xi}{K_j}\right]$$

$$\gamma\left[X_j - X_i\right]$$

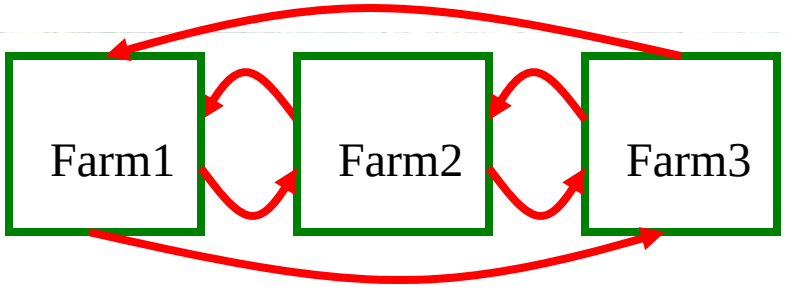


Wildlife diffusion and conservation

Closed

$$\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

Fully connected

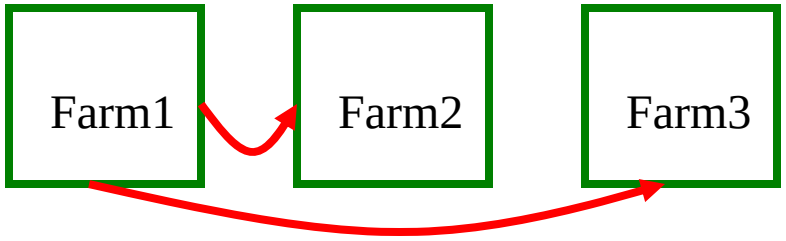


$$\begin{pmatrix} -2 & 1 & 1 \\ 1 & -2 & 1 \\ 1 & 1 & -2 \end{pmatrix}$$

Linear

$$\begin{pmatrix} -1 & 1 & 0 \\ 1 & -2 & 1 \\ 0 & 1 & -1 \end{pmatrix}$$

Sink-source



$$\begin{pmatrix} -2 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}$$

Simulation model setting

- Equation of motion

$$\forall i = 1...n \qquad X_i \left[\alpha \left(1 - \frac{X_i}{K_i} \right) \right] + \sum_{j=1}^{n} d_{ij} X_j = 0$$

- Habitat investment function

$$K_i = \bar{K} + K_g \left(1 - e^{-\delta p_i} \right)$$

- Objective function: maximize wildlife population at steady state

$$\underset{p_i}{Max} \sum_{i=1}^{n} X_i$$

- Budget constraint

$$\sum_{i=1}^{n} p_i c_i \leq \mathrm{B}$$

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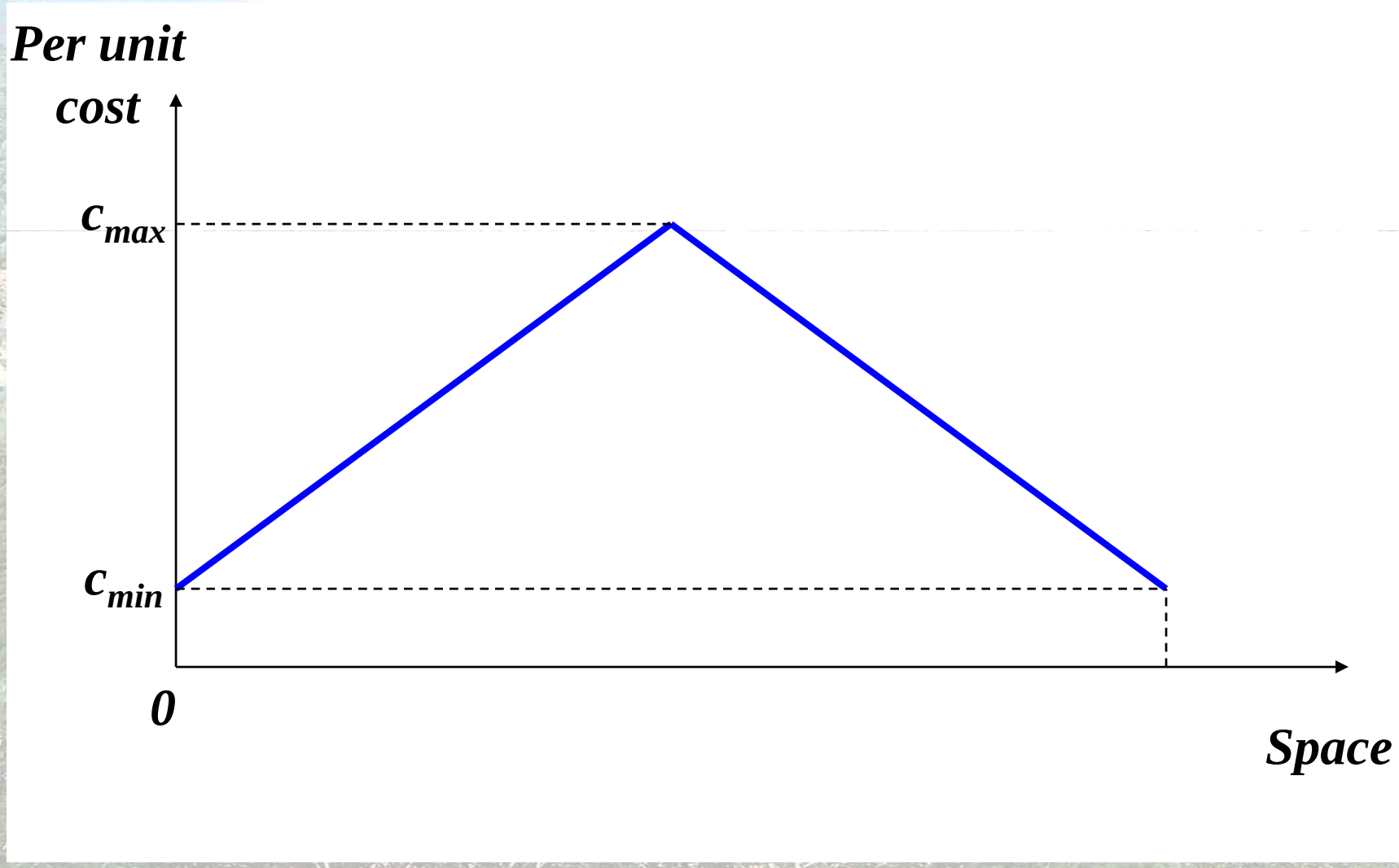
Simulation model setting: cost as the source of heterogeneity



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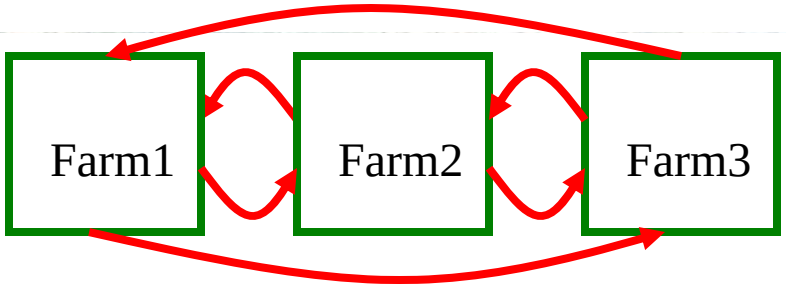

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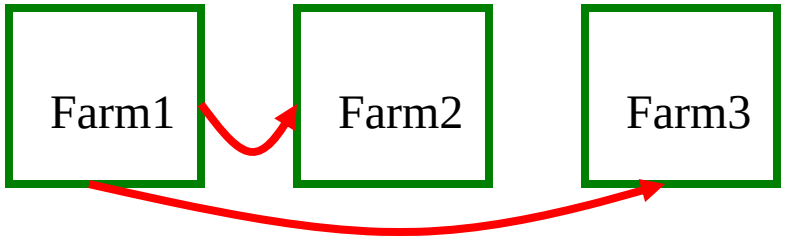

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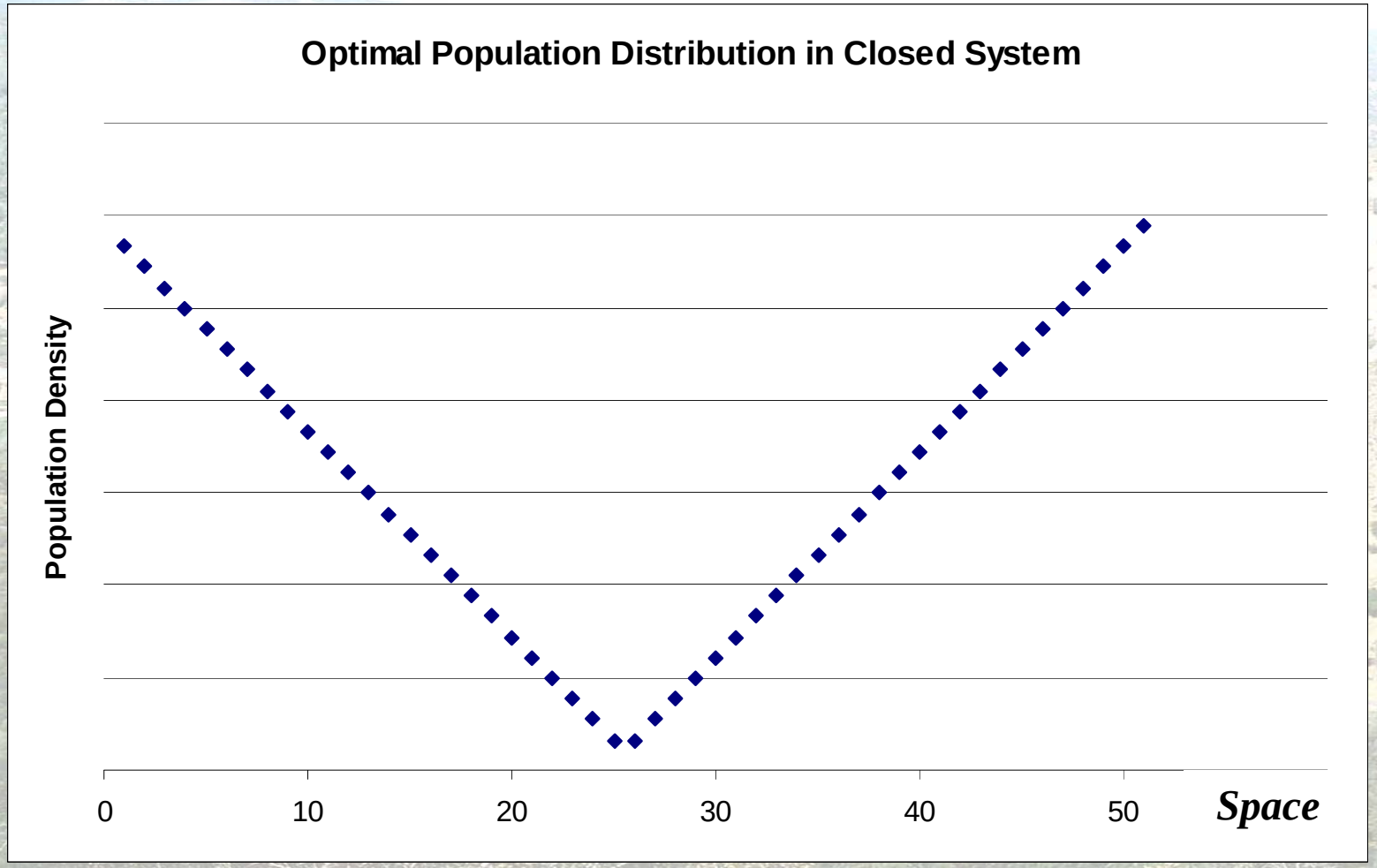
Impact of diffusion on optimal population pattern: preliminary simulation



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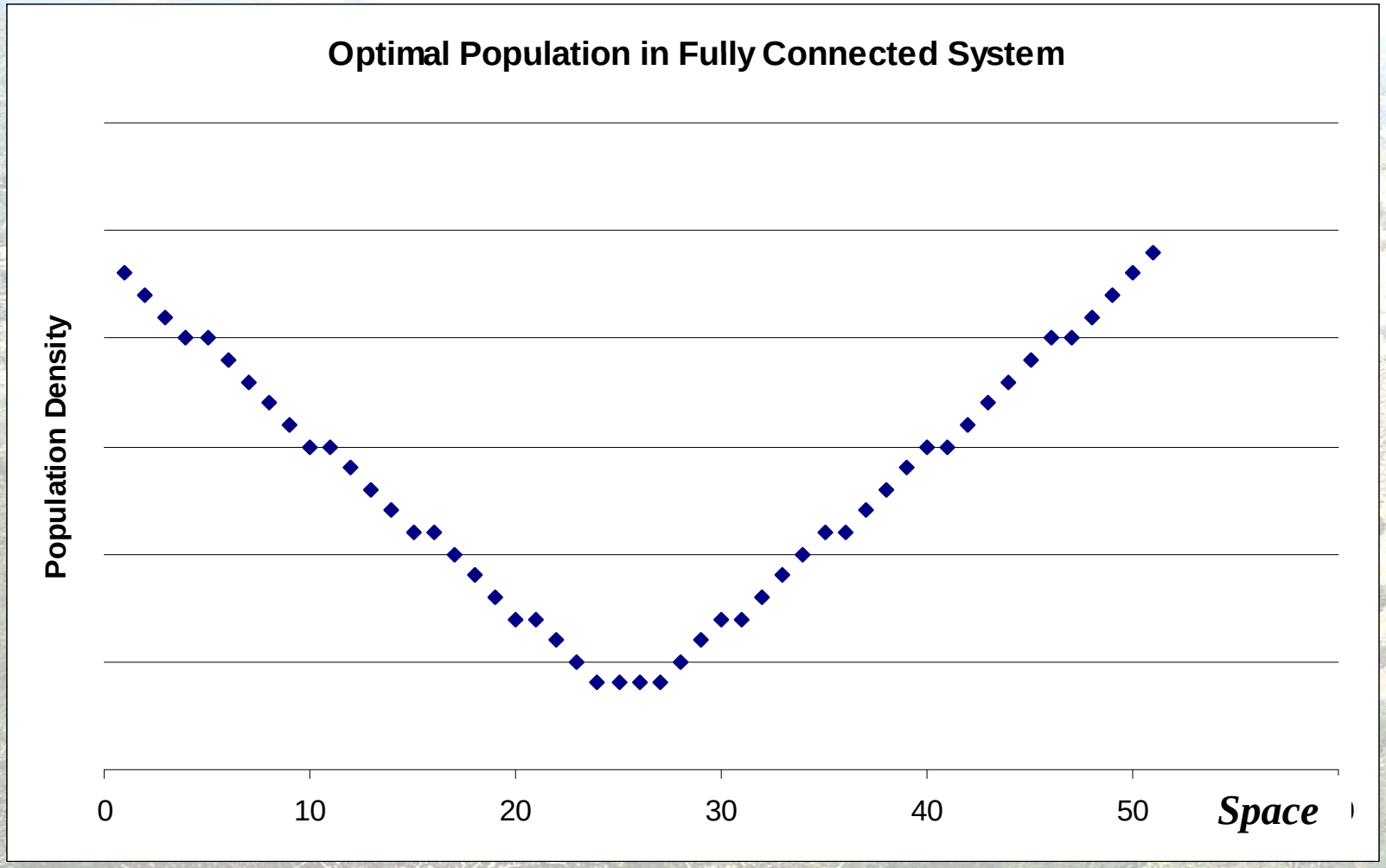

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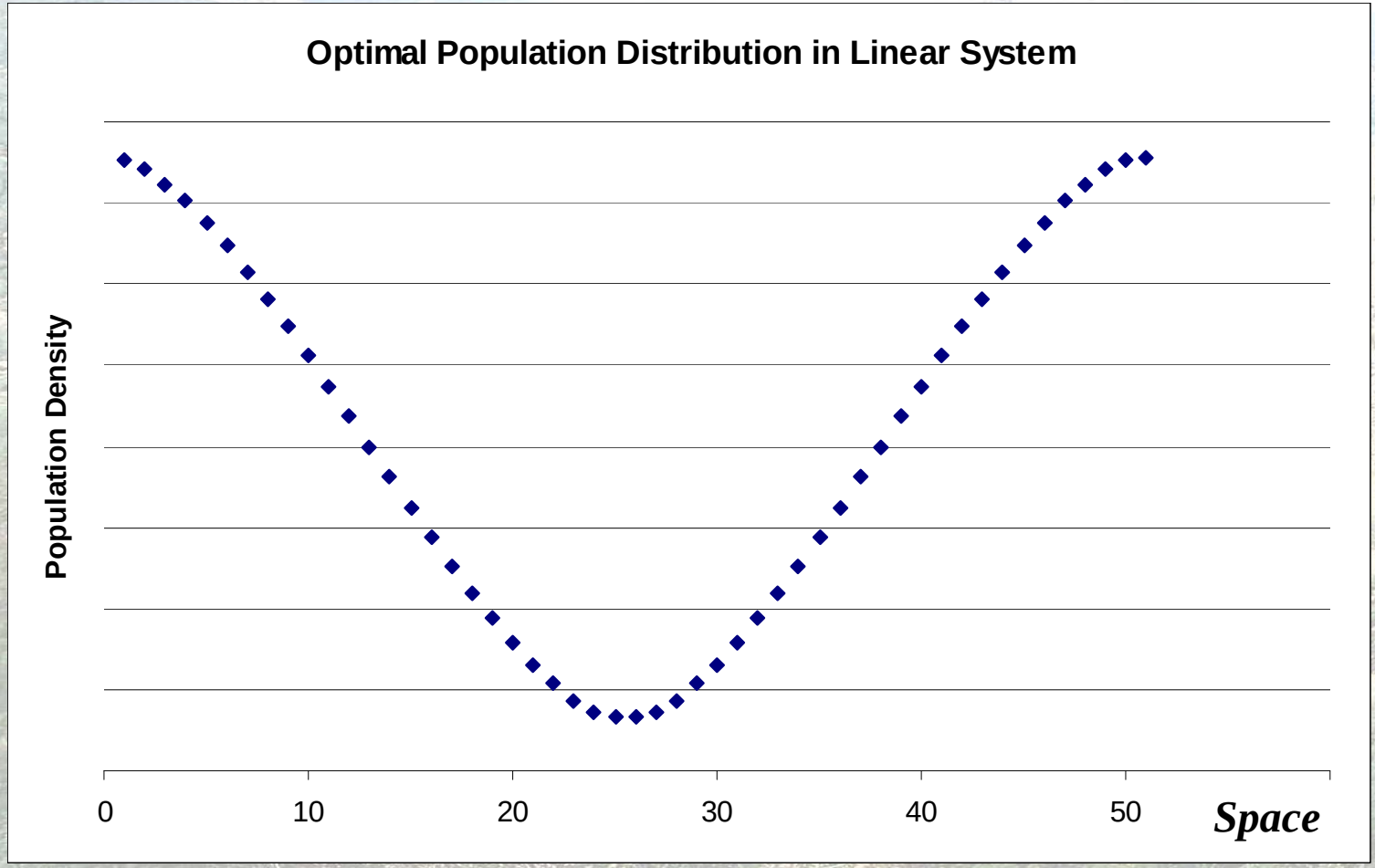

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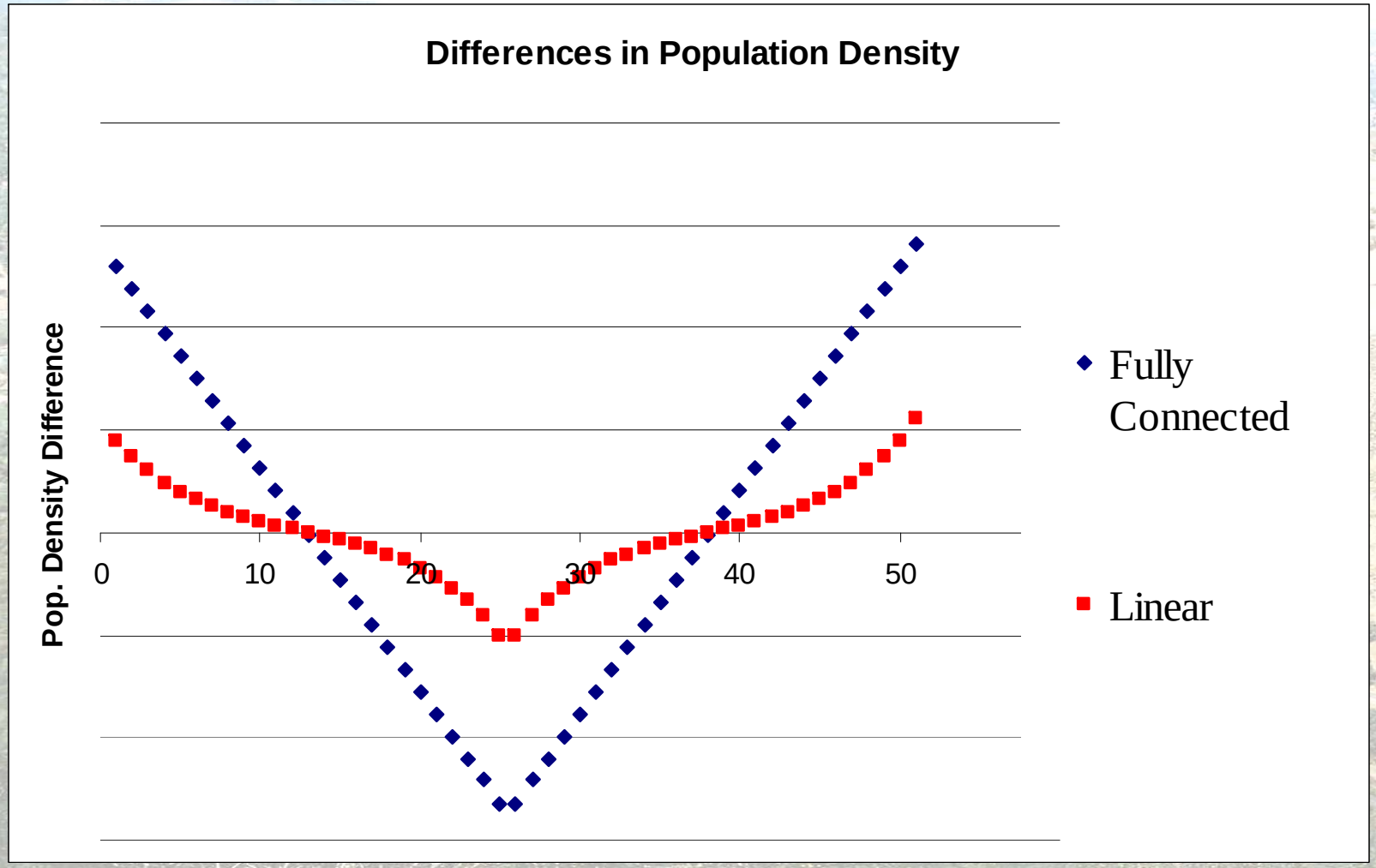
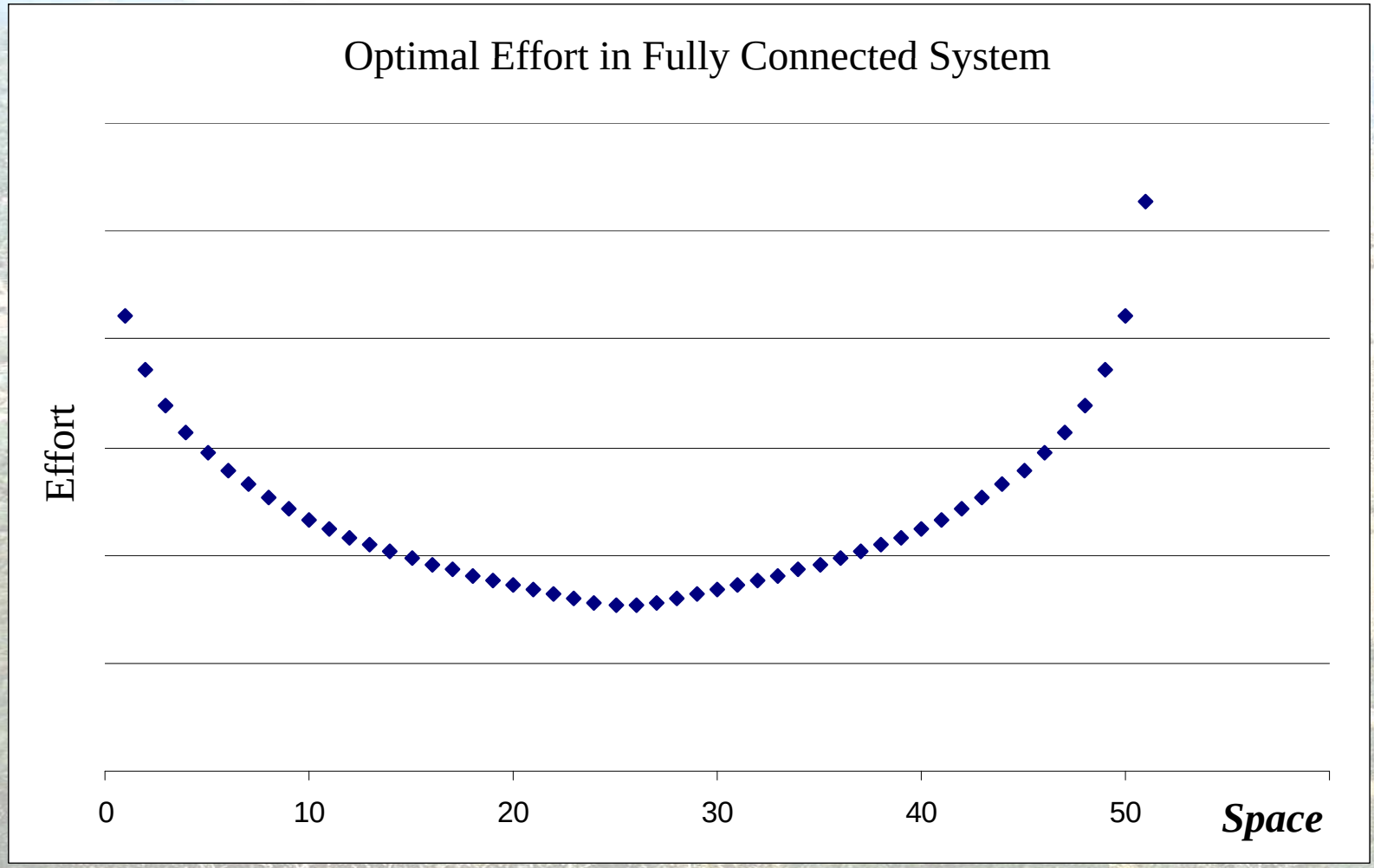


Impact of diffusion on optimal conservation effort pattern



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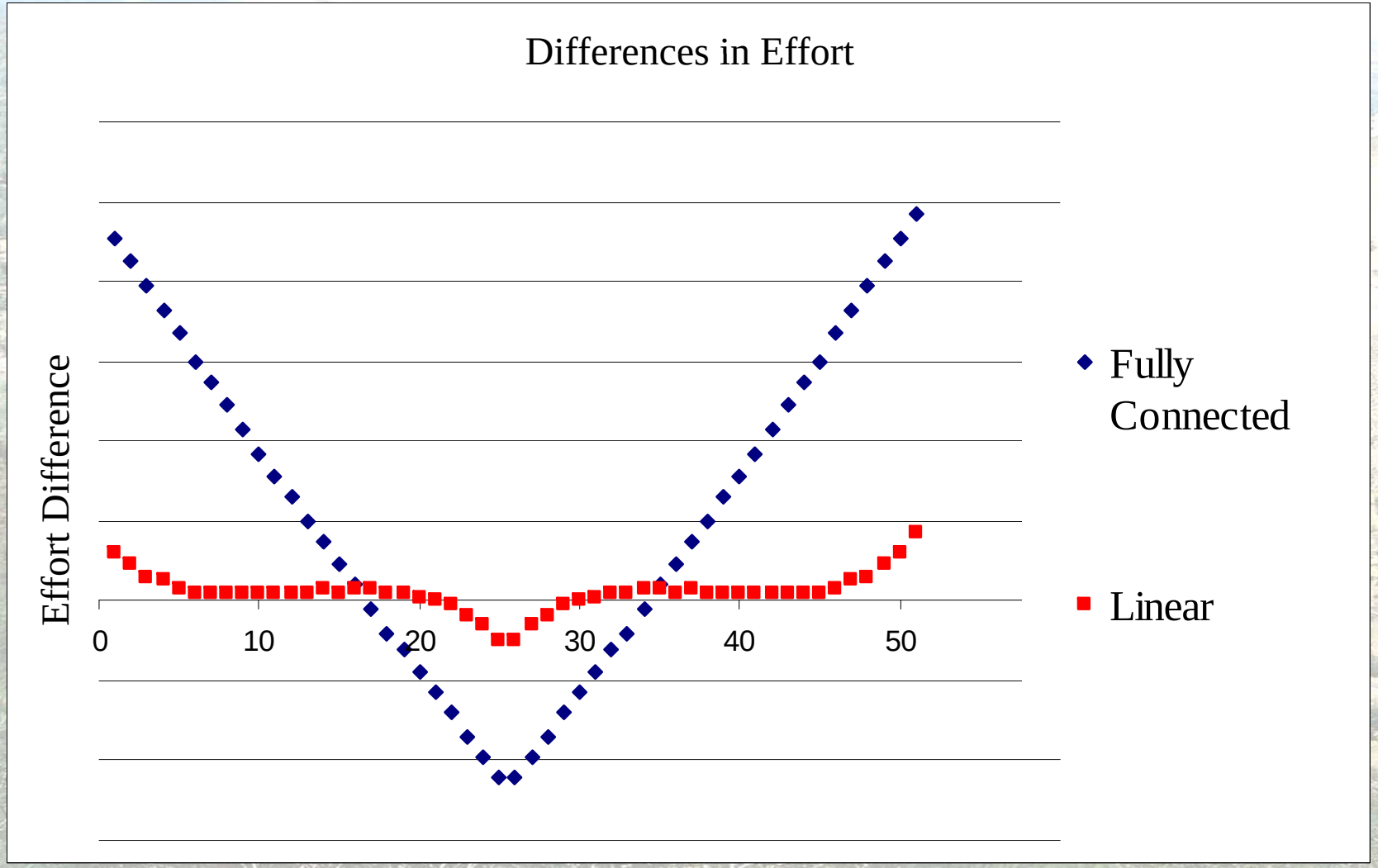
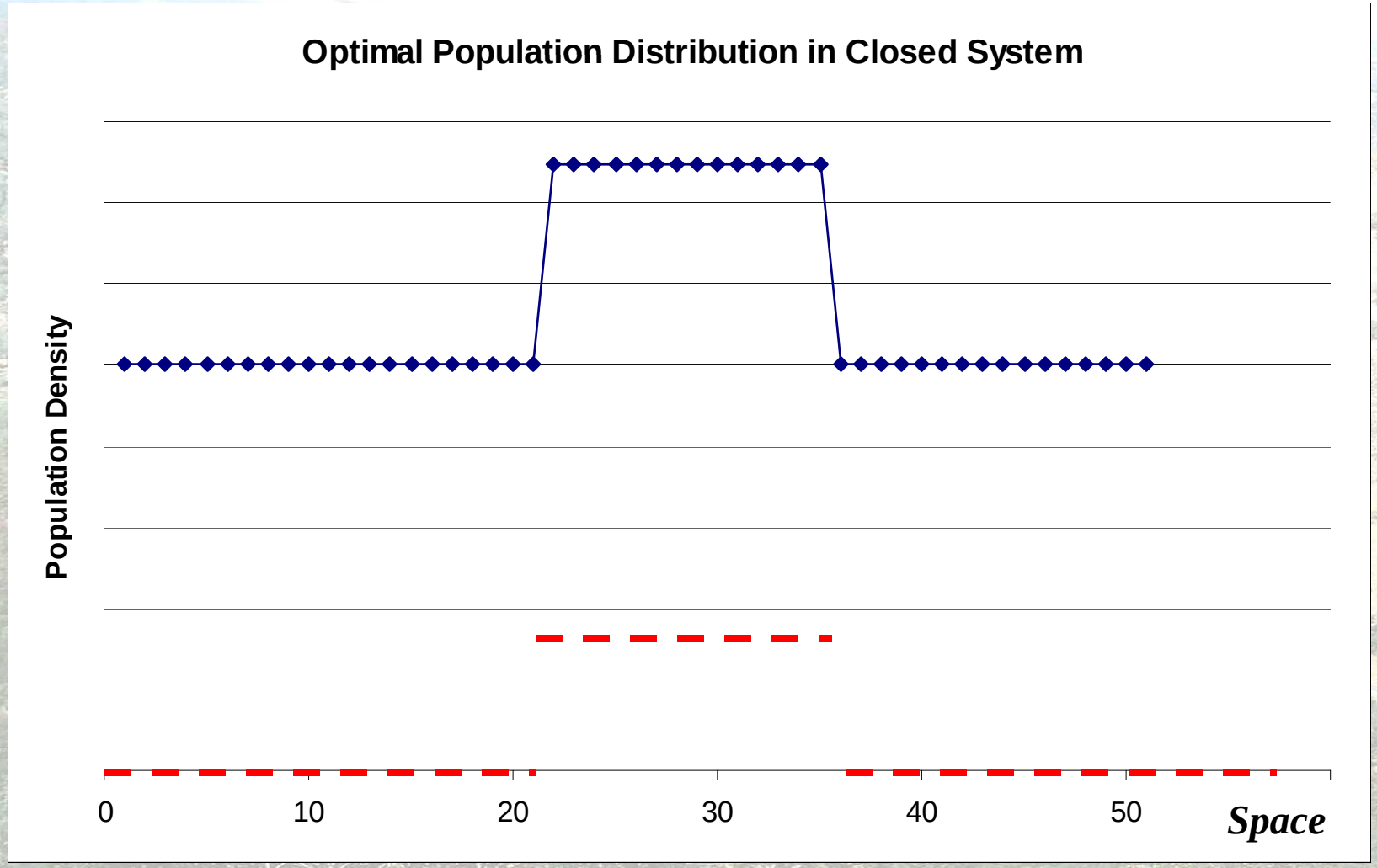


Fixed payment performance with diffusion



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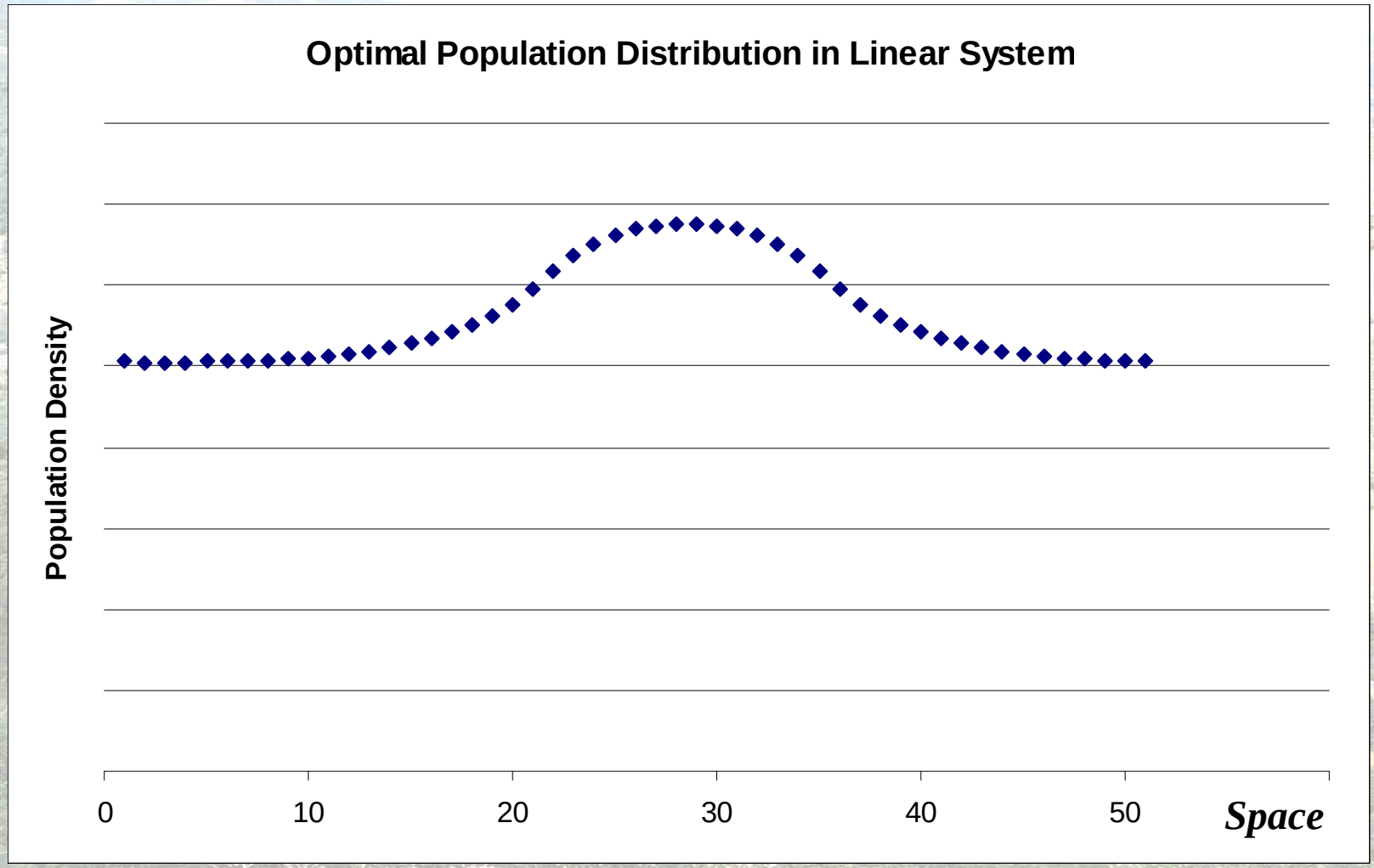

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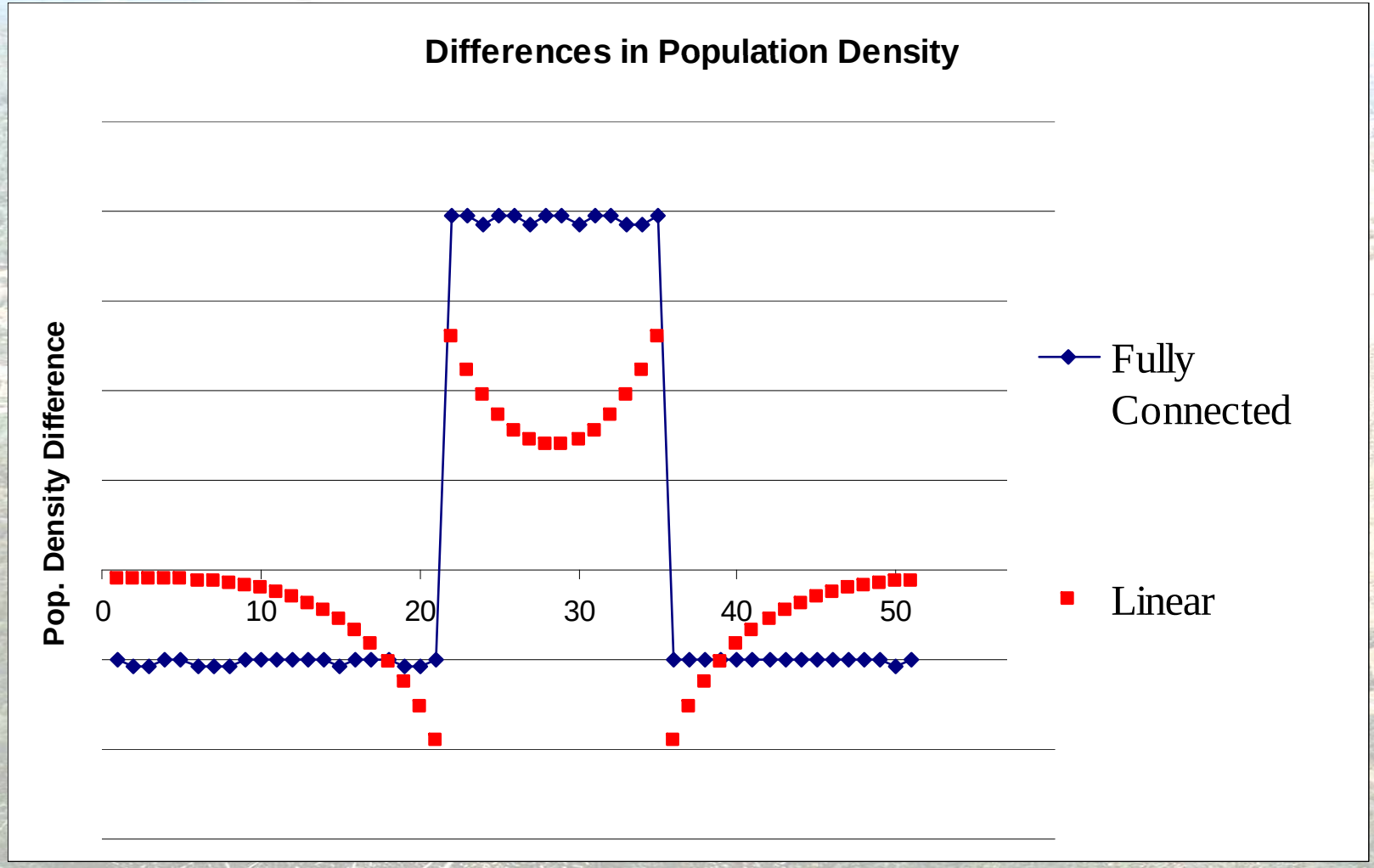


Fixed payment performance with diffusion

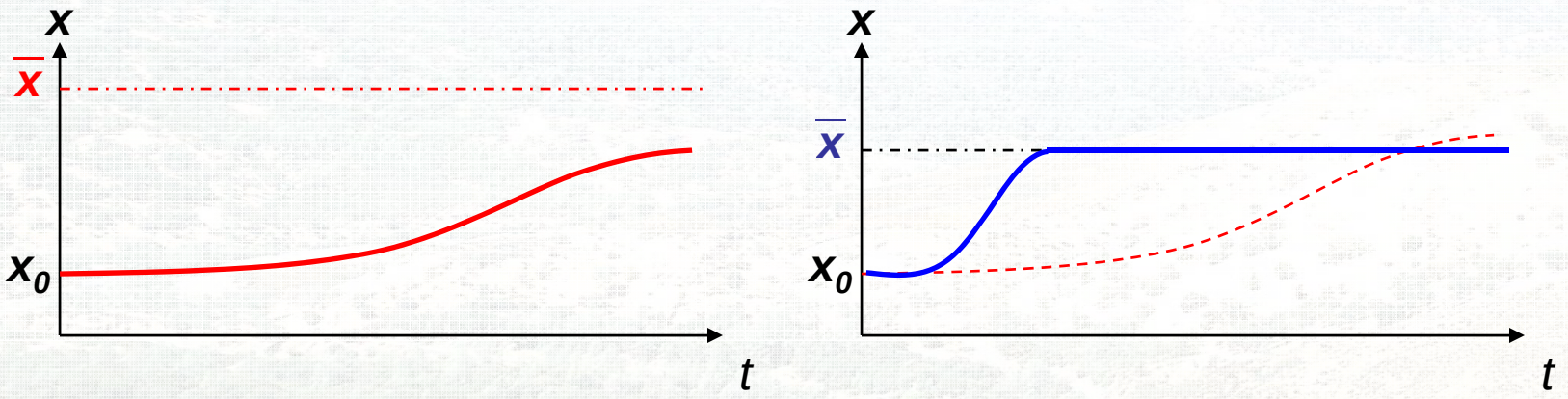
		Total Population	Effort Units
Social Planner	**Closed**	734.913	121.863
	Fully Connected	734.568	120.694
	Linear	734.88	121.754
Fix Payment	**Closed**	579.076	60.662
	Fully Connected	561.902	96.614
	Linear	573.622	60.662

Next steps

- Are informative analytical results possible?
- Sensitivity Analysis (use global v.s. local)
- Information Asymmetry
- Dynamics: what is the best trajectory for conservation
- Look more carefully at diffusion processes?

Finding a good objective function for conservation

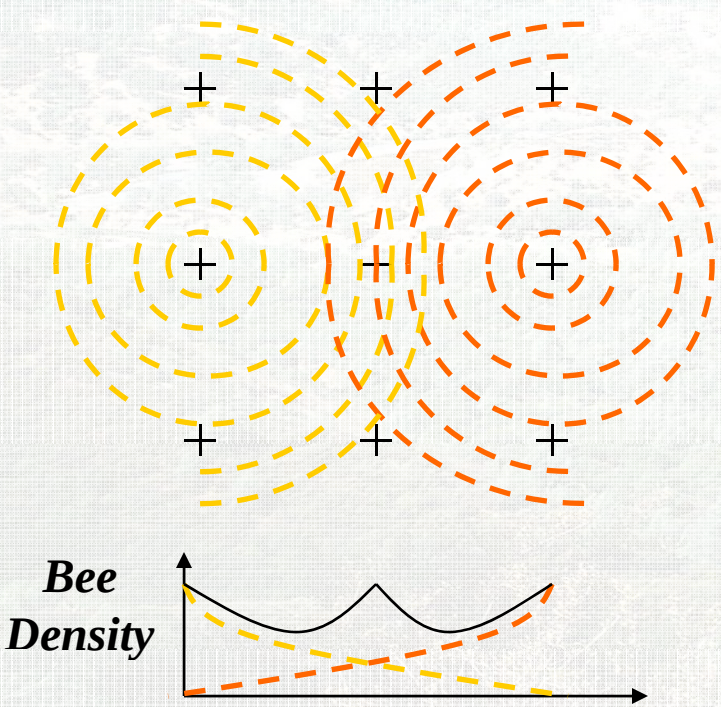
- Taking population trajectory into account

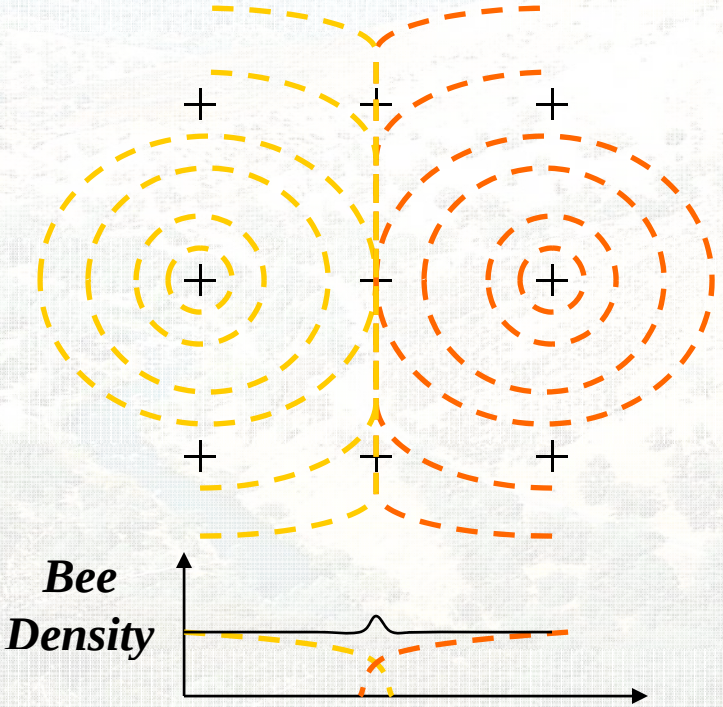


- Conservation = ?
  - High population density (spatially weighted?)
  - Low extinction probability as a species? As a population?
  - Biodiversity or ecosystem-scale conservation

Is “general” general enough?

- The case of honey bees and pollination





Conclusion

Other important issues:

- Multiple environmental services
- Different scales (local/global)
- Monitoring and environmental variability
- Effects on production

Quite a few questions left, eh?

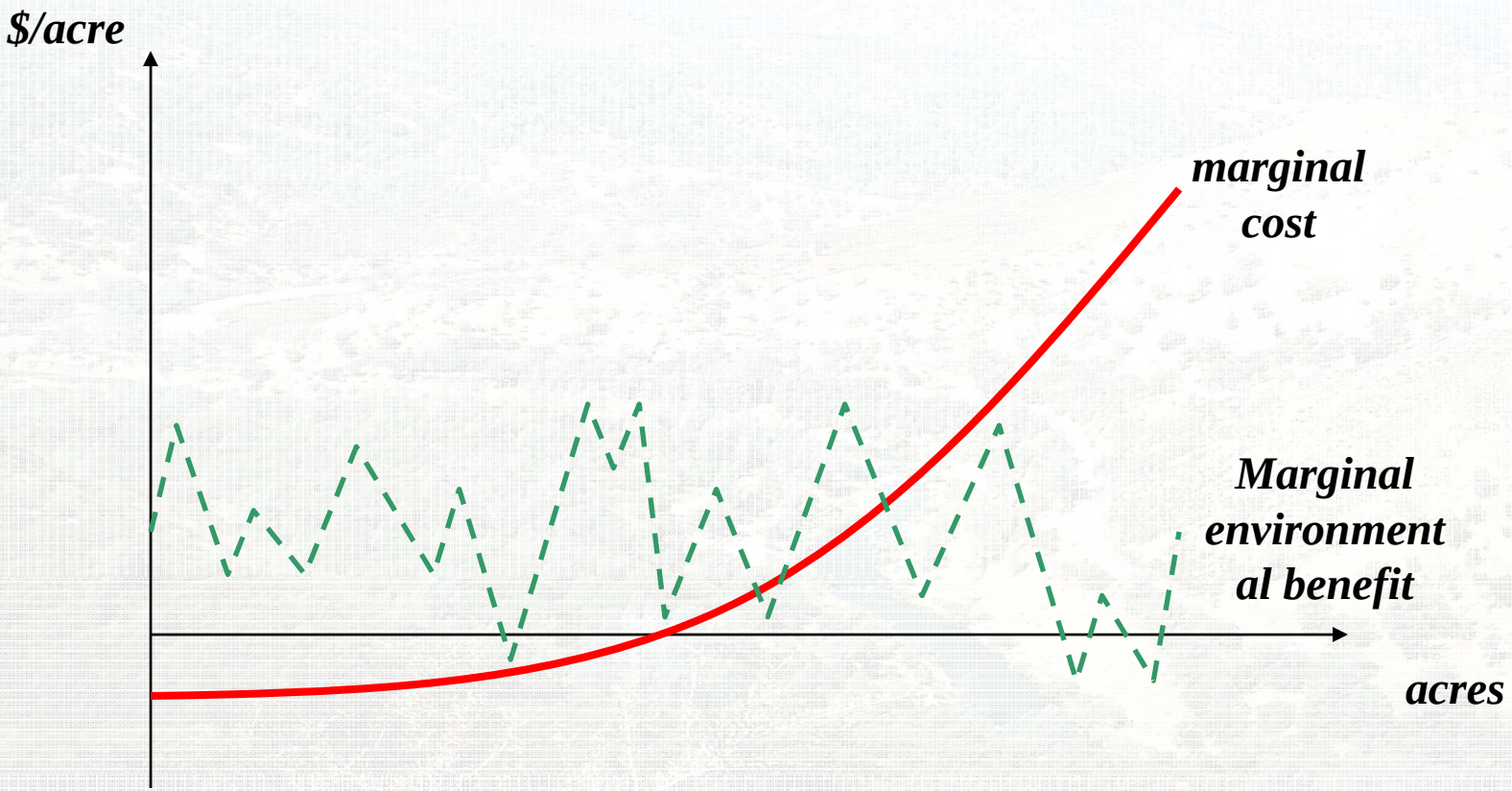
References

- OECD (2005) “Evaluating Agri-Environmental Policies: Design, Practice, and Results.” OECD Publishing

- Sanchirico, J. N. & Wilen, J. E. (1999) ” Bioeconomics of Spatial Exploitation in a Patchy Environment “*Journal of Environmental Economics and Management*, 37, 129-150

- Stoneham, G, V. and Chaudhri (2000). “Auction design for land-use change in the Murray Darling Basin.” Department of Natural Resources and Environment, Melbourne, Vic.

The cost-efficiency challenge of agri-environmental programs



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