Parks, buffers, and REDD instruments in an ecological-socioeconomic setting

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Model Structure

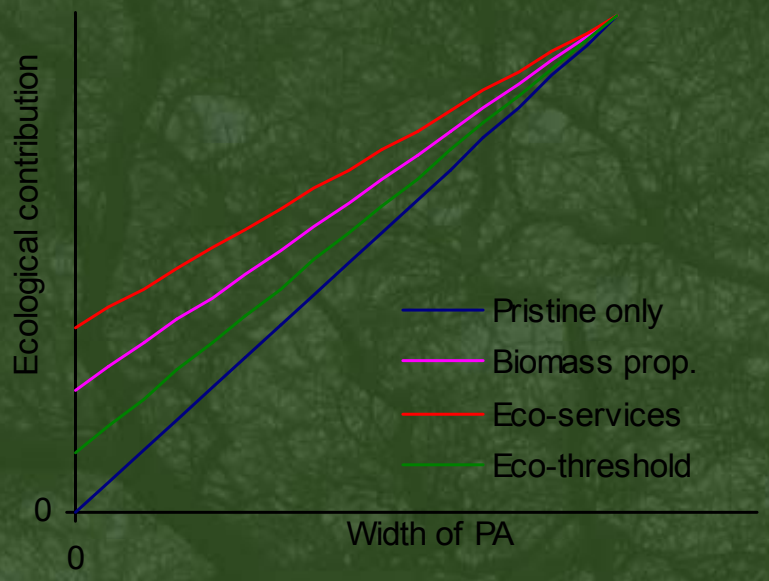
- FD: decision about size of PA
  - How much of the forest to protect
  - How much of the forest as extraction zone
  - Enforcement costly (but complete)
  - Mandate: PA-only, welfare, landscape
- Villager: intensity of extraction
  - Distance creates a cost
  - Amount of resource in extraction zone
- Game-theoretic framework
- Socioeconomic and Ecological setting

Ecological Damage Functions (EDFs)

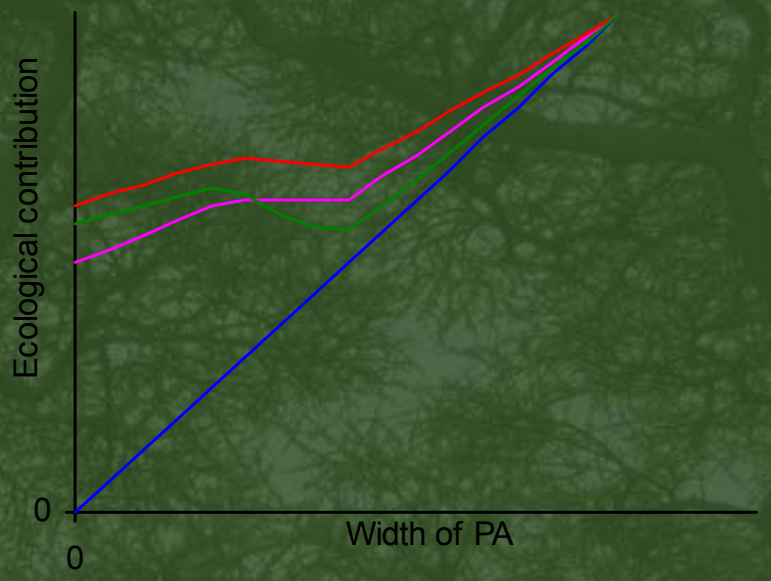
- Pristine-only
  - $E(m-h)=1$ if $h=0$
  - $E(m-h)=0$ if $h>0$
- Biomass-proportional
  - $E(m-h)=(m-h)/m$
- Ecoservices
  - $E(m-h)=((m-h)/m)^{\beta}$, $\beta<1$
- Eco-threshold (logistic)
  - $E(m-h)=1/(1+\theta\exp(-b(m-h)/m))$

Results: Ecological Setting

γ=1,
t=0



γ>1,
t>0

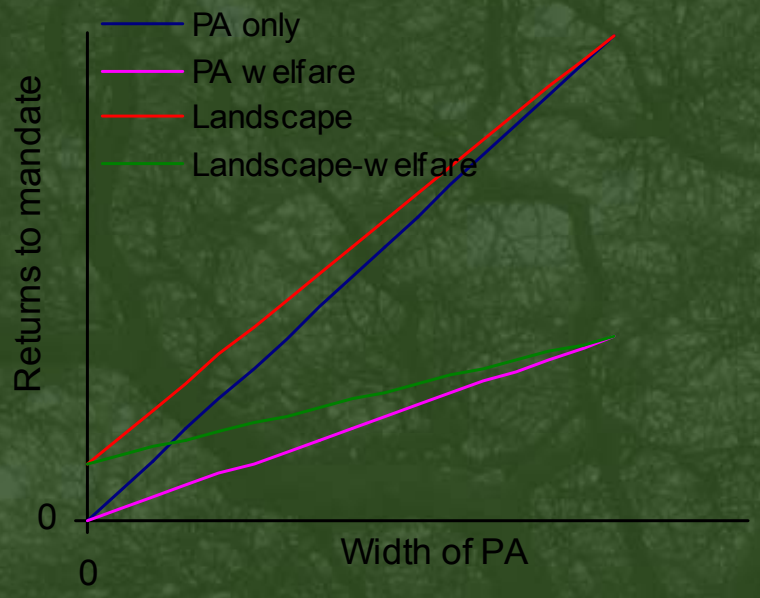


Results: Ecological Setting

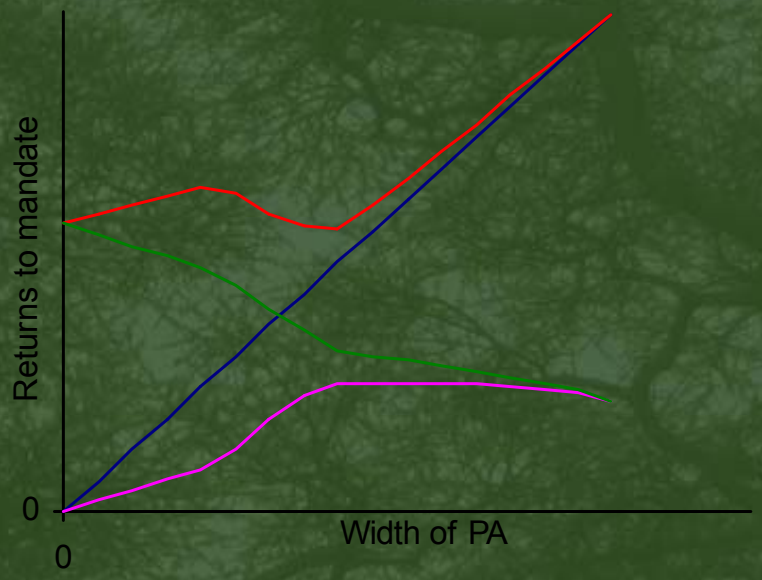
- With easy markets, larger PA = more ecological benefits, regardless of EDF
- Without such markets, local minima for ecological benefits for non-pristine-only EDFs
  - May want small parks with large buffer zones

Results: Returns to PA Mandates (w/ eco-threshold EDF)

γ=1,
t=0



γ>1,
t>0



Policy Implications

- Siting/Sizing parks
  - Function of ecology, markets, and policy
  - People's reaction
  - Framework underpins sizing decisions
  - No one-size fits all parks
- REDD
  - Difficult to monitor degradation
  - Framework could underpin probabilistic monitoring approaches
  - Need for behavioral spatial models rather than site-characteristic probabilities

Next Steps and Calls for Research

- EDF shapes
  - Valuation of ecosystem services as a function of degradation
- Include spatial ecological benefits
- Include spatial enforcement costs
- Combine with incomplete enforcement
- Dynamics
- Combine with spatial behavioral model for forest clearing
- Empirical work on spatial costs

Conclusion

- People React!
  - Ecological costs from displacement
  - Welfare effects
- Integrate ecological goals with social goals/mandate in sizing/siting PAs
- Both the market and the ecological setting matter for the optimal PA size
- Park and REDD policies require spatial behavioral models

Questions and Comments?

The FD's Decision

Where X_P is the width of the PA, E is the ecological value function, m is the resource density, h is the harvest level, P is the welfare penalty, and e is the enforcement cost

$$\max_{X_P}\{W\} =$$

$$\max_{X_P}\begin{Bmatrix} \delta_1 X_P + \delta_2\left(\overline{X} - X_P\right)E\left(m - h\left(X_P\right)\right) \\ -\delta_3 P\left(\mathrm{X_P}\right) - \delta_4 e X_P \end{Bmatrix}$$

Villager's Decision

$$\max_{w}\{V\} = \max_{w}\{(p-t)S-(p+t)D-C\}$$

subject to:

$$D-S=R-H \qquad H,S,D\geq 0 \qquad SD=0$$

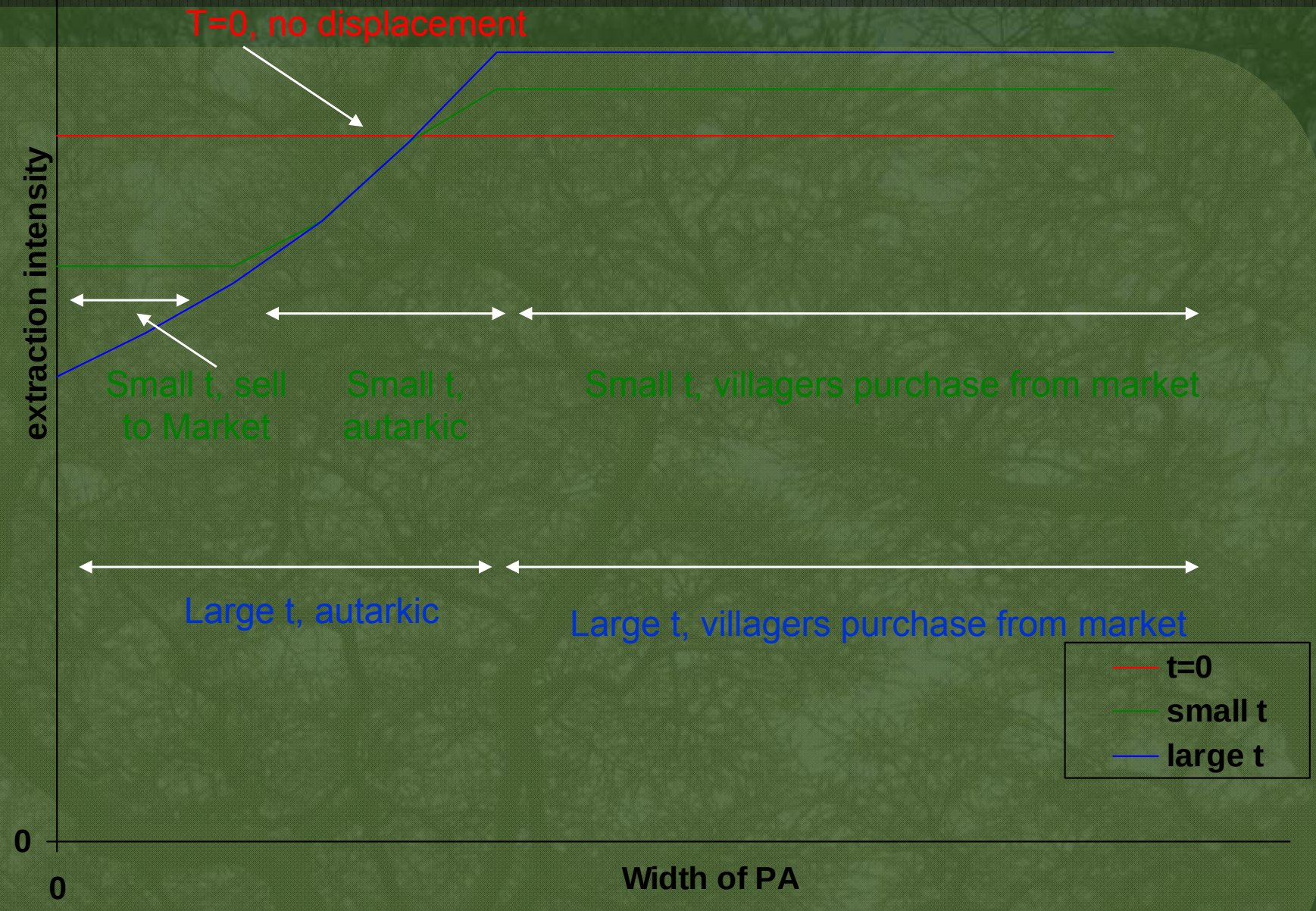
$$H=h(\bar{X}-X_P) \qquad C=C((w+v)X)$$

Specifically here:

$$h=m\left(1-\frac{1}{(1+\alpha mw)}\right) \qquad C=k((w+v)X)^{\gamma}$$

where w is the time in the forest beyond walking time v, p is the resource price, t is the market transactions cost, D is the deficit, S is the surplus, R is the requirement, and H is the harvested amount. $\gamma>1$ implies increasing costs to time.

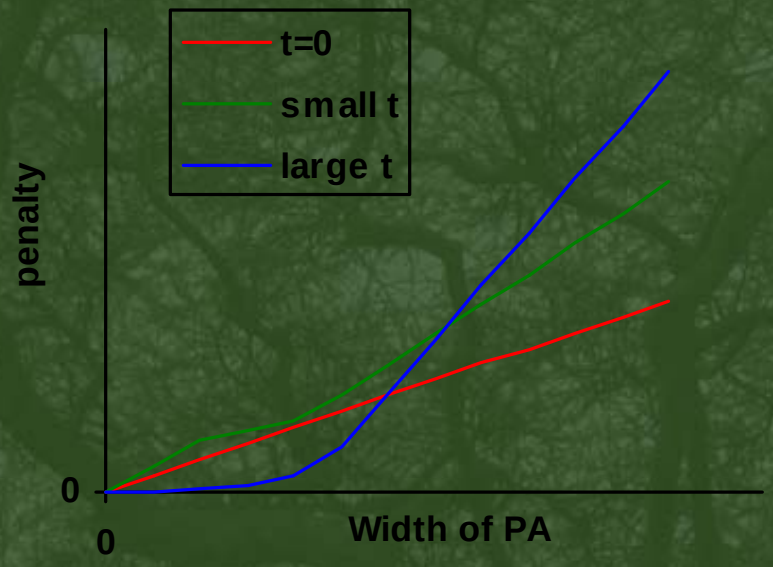
Results: Economic Setting with γ=1



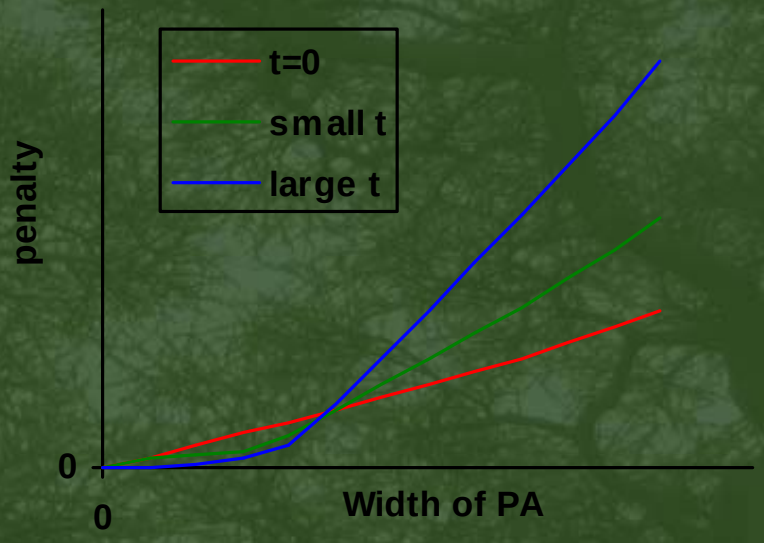
Results: Economic Setting with γ>1

Results: Welfare Penalty

$\gamma = 1$



$\gamma > 1$



Results: Socioeconomic Setting

- No displacement if
  - no-cost markets (t=0 and γ=1)
  - w/ γ=1, and t>0, but interacting w/market
- Largest displacement when subsistence
- Highest welfare penalty when
  - Interact with market
  - High market access costs
- Local minima suggest max PA not best