Green Growth
Lessons from Growth Theory

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Green Growth

- How to implement sustainable development in the short to medium run (Heal)?

- Improved human well-being and social security, while significantly reducing environmental risks and ecological scarcities (UNEP)

Focus on:

- Correcting market failures (Heal)
- Sound regulatory frameworks; employ market-based instruments
- Value of Natural Capital as a key component of social wealth: ecosystems , nonrenewables, renewables

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Lessons from growth theory

Basic framework

Extensions

- Climate change
- Technological progress

1. Basic Framework

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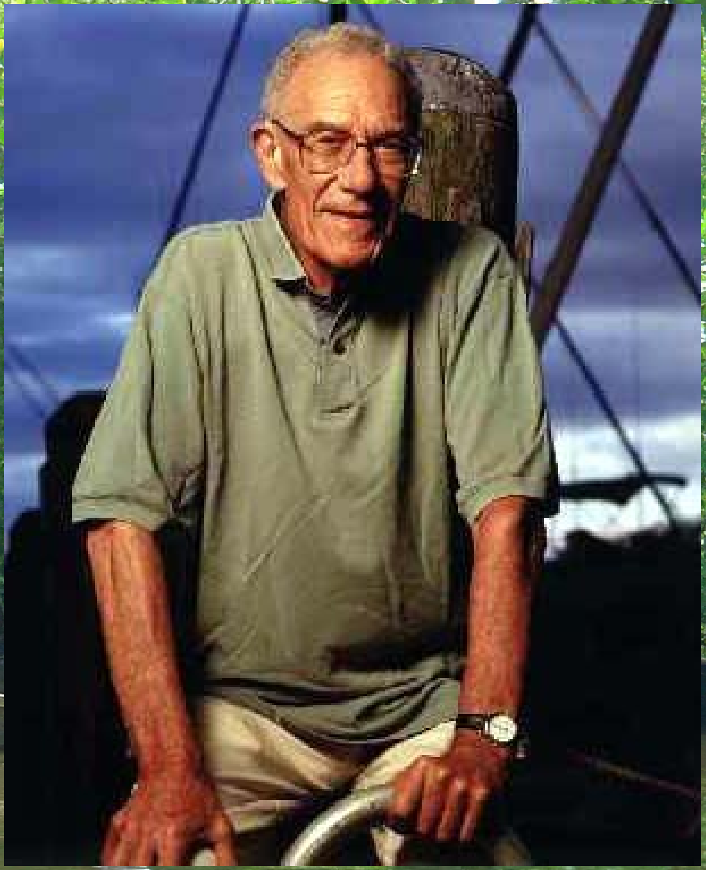
Ramsey

Solow



How much should a nation save?

Standard model

- Objective is maximal social welfare over time = *present value* of individual welfare over time, depending *only* on individual material consumption (not on environmental quality)
- If the "rate of time preference" is high then present generations are given priority – more consumption, less savings for the future
- Other factors influence the distribution of welfare over time (e.g. elasticity of intertemporal substitution (EIS). Low EIS is preference for flattening consumption path)

- Production depends only on capital (no environmental impacts on production)

Key Results

- In optimum:

benefit of extra current consumption=

cost of extra current consumption=

value of capital=

present value of future welfare made possible by

capital accumulation

- *Change in value of capital = rate of return on investment = interest rate*

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Key Results (Capital)

- Economy approaches a constant level of capital where marginal product equals sum of time preference and depreciation rates
  - High impatience and/or high capital depreciation “conspire” to keep capital stock low

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Key result (Consumption)

- Consumption grows so long as rate of return on investment (net of depreciation) is larger than the rate of time preference

- Consumption growth rate depends a.o on elasticity of intertemporal substitution. With low EIS low consumption growth, flat consumption path

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2. ***Environment and Growth*** – the Example of Climate Change

Extending the Modeling Framework

Key elements:

- Production depends on built capital and energy inputs
  - Cost of CO_2-emitting fossil fuel ("oil") rises as resource base is depleted
  - Renewable energy is a constant-cost "backstop" with higher initial unit cost
- Concentration of CO_2 in the atmosphere negatively affects instantaneous *welfare*

Questions:

- What does the transition to a low-carbon economy look like in social optimum?
    - How does switching time depend on state of development?
- How does a market economy outcome compare?
- How to bring the market to the social optimum?
    - First-best versus second-best?

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Results

- Economy approaches carbon-free steady state in social optimum
  - Transition to renewables occurs in part because of rising fossil fuel supply costs and in part because of environmental damage
- Transition to renewables depends on stage of economic development
  - Very low initial fuel stock => no fossil fuel use (too high extraction costs)
  - Moderate initial fuel stock => optimal to use fossil fuel for increasing capital before transition to costlier renewables
  - Large initial fossil fuel stock => fast growth of capital, beyond carbon-free steady state, with return to steady state with oil and renewables used in tandem

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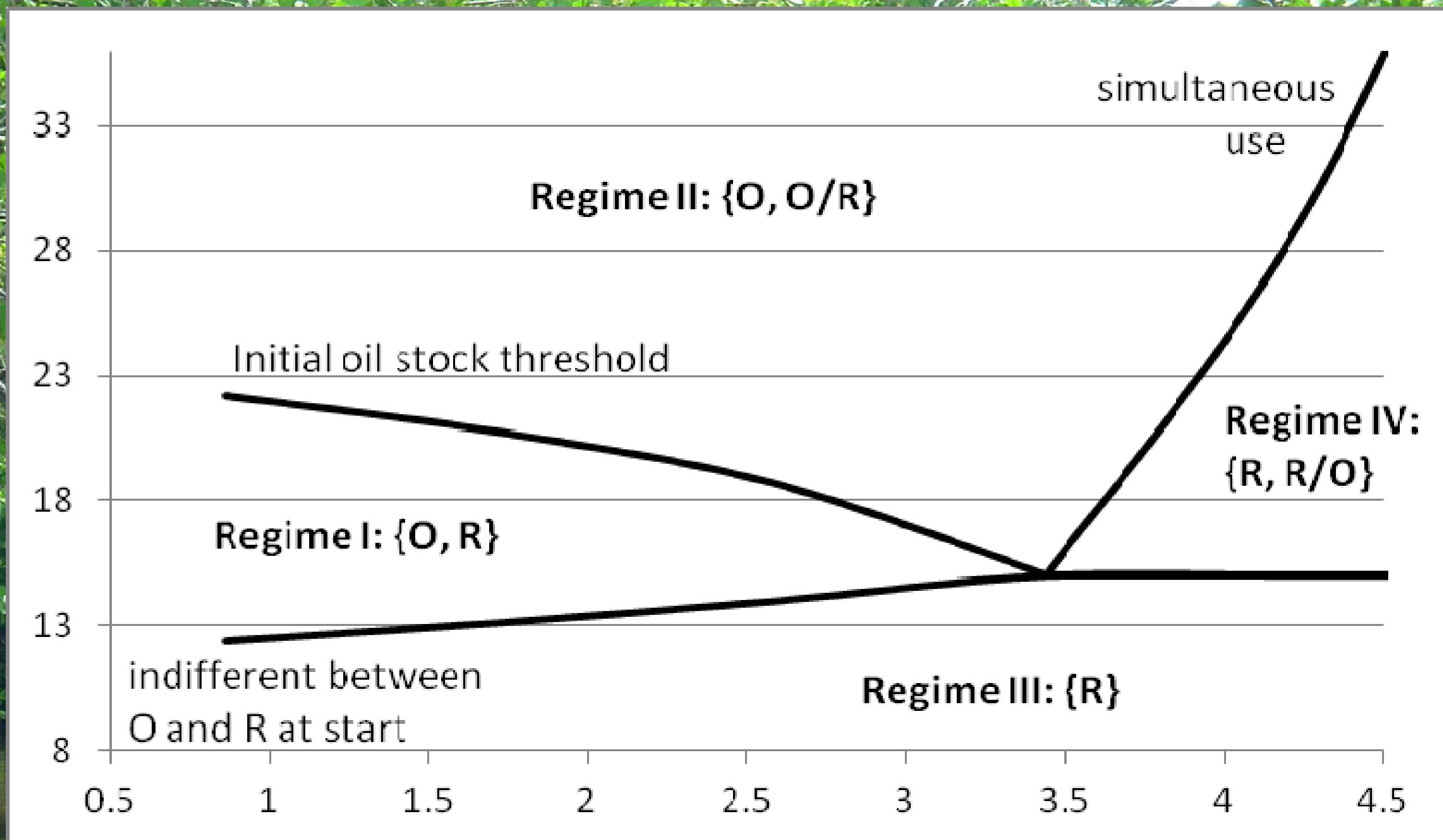
Optimum Growth Paths



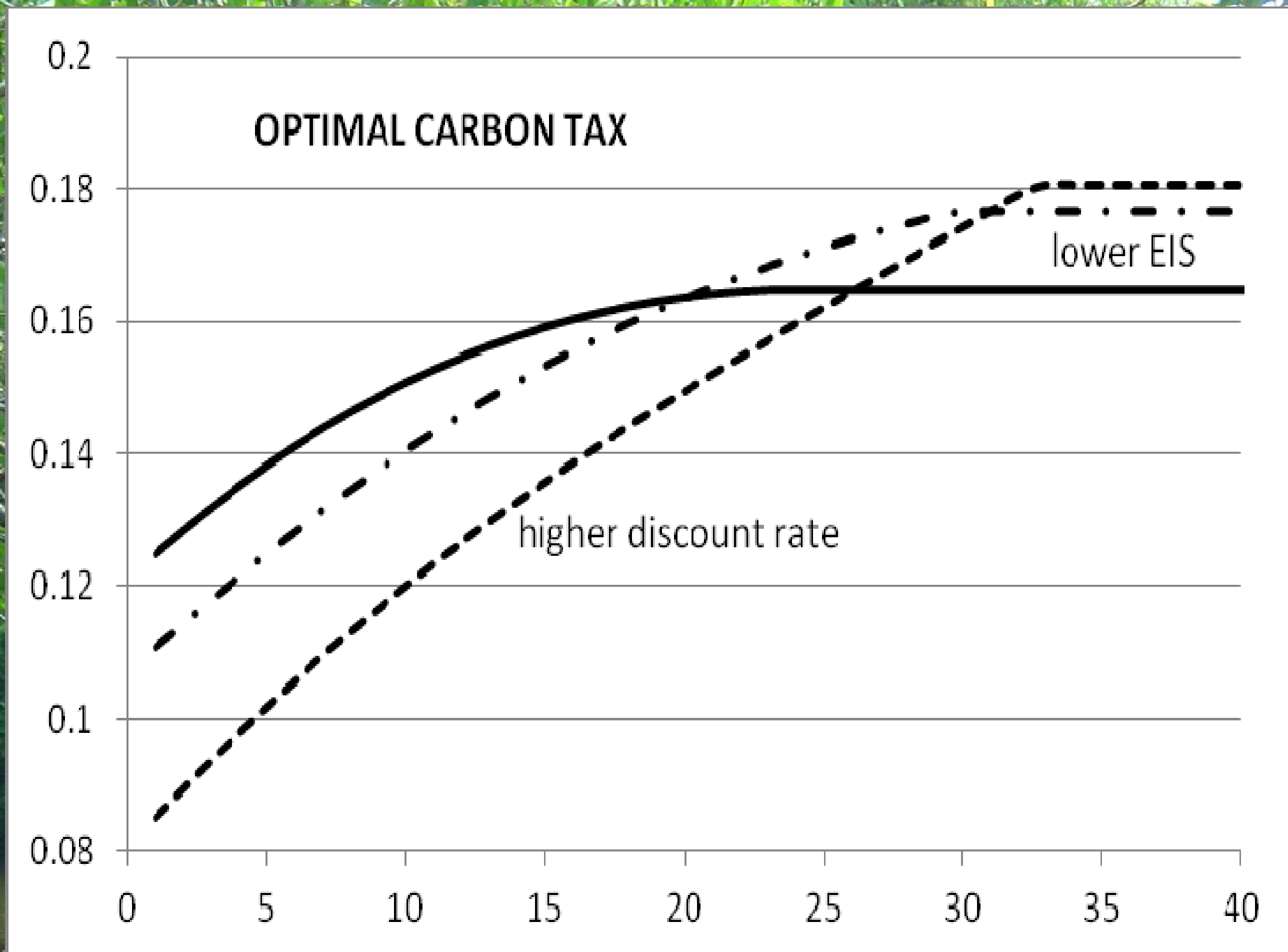
Oil stock →

Capital stock →

Optimal Carbon Tax

- Magnitude of optimal (global) carbon tax over time reflects discounted social damage looking forward
- Increasing over time in a growing economy, up to some long-run value that sustains the transition to a low-carbon economy
    - Reflects anticipation of higher future cost per unit of emissions as (global) economy and emissions concentration grow
- Depends on rate of time preference and EIS

Optimal Carbon Tax



time →

Second-best

In absence of optimal carbon tax

- Subsidy on renewables?
- Larger subsidy for renewable R&D?
- Green Paradox

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Extensions to "Ecosystem Services"

- Concern is with natural resources and ecosystem characteristics that are "public goods" (markets cannot efficiently manage)
- Supply depends on intensity of "extraction" of services and changes in "health" of ecosystems over time
- Simple model of optimal fisheries management can provide some basic insights:
  - Optimal use ⇔ current incremental benefit = long term cost of ecosystem degradation/depletion
  - Some depletion is efficient (can use ecosystem services more intensively to raise output and savings to increase built capital)
  - Over-depletion (e.g. open access) => rate of return from reduced use to promote recovery > rate of return from other savings
  - Optimal use patterns depend on state of development (greater return from more intensive use for economies with lower income and built capital)

Policy Implications – Summary

While stylized, growth-and-environment models highlight key influences on sources of inefficiency when environmental externalities and public goods are not adequately addressed.

- The 'right' prices depend on preferences, as well as resource and built capital stocks .
  - Degree of impatience is a key factor, as well as how marginal utility of consumption changes
  - Especially challenging to assess 'right' price *paths* in dynamic context
- Optimal prices depend on stage of development.
  - No simple answer for price level *or even trend*; interactions with other influences on productivity, capital accumulation
- Need for disaggregated approach

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3. Technology and Innovation

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Growth and Technical Change

- GDP Growth follows from
  - Growth in inputs (capital, labor, energy, natural resources)
  - Growth in efficiency
  - Growth in productivity (= technical change)
- Technical change is the main driver of growth
  - New production process, materials and products
  - Skills
  - Diffusion as well as innovation → technical change
  - Capital accumulation is spurred by productivity changes

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Green Policies and Growth

- Green Policies reduce pressure on environment → lower levels of polluting inputs
  - Reduced environmental damages → higher current and longer-term well-being
  - Extent of positive impact on growth and (conventionally measured) consumption depends on circumstances

However,…

- opportunity cost of responses to green policies → "*Growth drag*"
  - For any given rates of technical change, growth will be slower
  - Standard growth-environment models do not model how technical change responds to environmental policy (no growth spillovers, economies of scale, "Porter effects")

Technical Change…

- …is endogenous (at least partly)
    - R&D, patents
    - Learning, experience
    - Adoption and diffusion
- …is an investment decision
    - Rate of technical change (fast versus slow)
    - Direction of technical change (green versus brown)

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Innovation and Potential "Limits to Growth"

- Capital accumulation
  - Diminishing returns → rate of return falls
- Fixed or declining resource inputs
  - Lower productivity of capital → rate of return falls
- Better technology
  - Higher productivity of capital → rate of return increases

So technical change can save us from stagnation, or even decline from severe natural capital depreciation, but only if strong enough

Why not "develop first, clean up/recover later"?

- Resulting scarcity of natural and environmental resources would outweigh the positive impacts of technical change
- Better "develop, innovate and conserve resources simultaneously"

Green Policies, Innovation and Investment

- Green policies might hurt investment and technical progress if capital and innovations are complementary to polluting inputs:
  - Inputs scarcer → return to investment and innovation lower → crowding out
  - Magnified growth drag: both capital accumulation and technology advance are crowded out
    - Increases overall economic rationale for retaining brown technology
- However, green policies might boost investment and technical progress if capital and innovations are substitutes to polluting inputs:
  - Polluting inputs scarcer → shift to cleaner sectors → higher return to investment and innovation here
  - → "Crowding in" of investment and green technology transition

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Shifts to green innovation?

- Policies affect incentives and direction of technical change
- Complete redirection of innovation from brown to green can be costly
- Lock in: increasing returns and history make sweeping green innovation too expensive for the private sector unless there is a “tipping tax”

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Shifts to green innovation?

- Effect of redirecting technical change to green…
  - Restricts menu of innovations to choose from (–)
  - But spillovers may be even bigger (–/+)
  - Market size should not be different (0)
- Not sure about the effect of redirection on overall technical change,…
- but (given the opposite forces listed above) no strong reason to expect much lower opportunities for innovation.

Policies Required

- Knowledge spillovers → too little innovation
- Subsidize Green R&D more than R&D in general?
  - We do not know difference in spillovers…
  - Yet: green growth means bigger spillovers since more sectors will use the knowledge (Samuelson rule)
  - So,... YES, green R&D subsidy is efficient

Second-best policies

Challenges to policy design:

- Difficult to target R&D
- Free-rider environmental problems (e.g. emissions leakage) also weaken incentives for innovation

Second-best solutions:

- Adoption subsidies
- Emission taxes have double task: not only reduce pollution but stimulate green technology and create spillovers.
- Labeling, technology standards, procurement

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Medium-Term Policy

- Stuck with current General Purpose Technology, which might be brown
  - Oil (transport) and (gas or coal-based) electricity
- Advent of new Green GPT random
  - Energy transitions have been very rare in history
- Policy implication: big role for effective environmental policies, rather than relying mostly on technology policies
- Focus on adoption and diffusion of existing green technologies
  - Learning and market size effects → critical mass

4. Conclusions

A Future of Green Growth?

- Nature is an asset – costs and benefits of its utilization need to be an integral part of growth planning and policy
- Growth is driven more by technical change rather than input growth
- Green growth is technically feasible
- Green growth requires environmental policies and technology policies
  - Otherwise technical change and sectoral shifts may worsen environmental quality
  - There is a large menu of possible policies
  - Cost of having imperfect policies rather than first-best policies is often small

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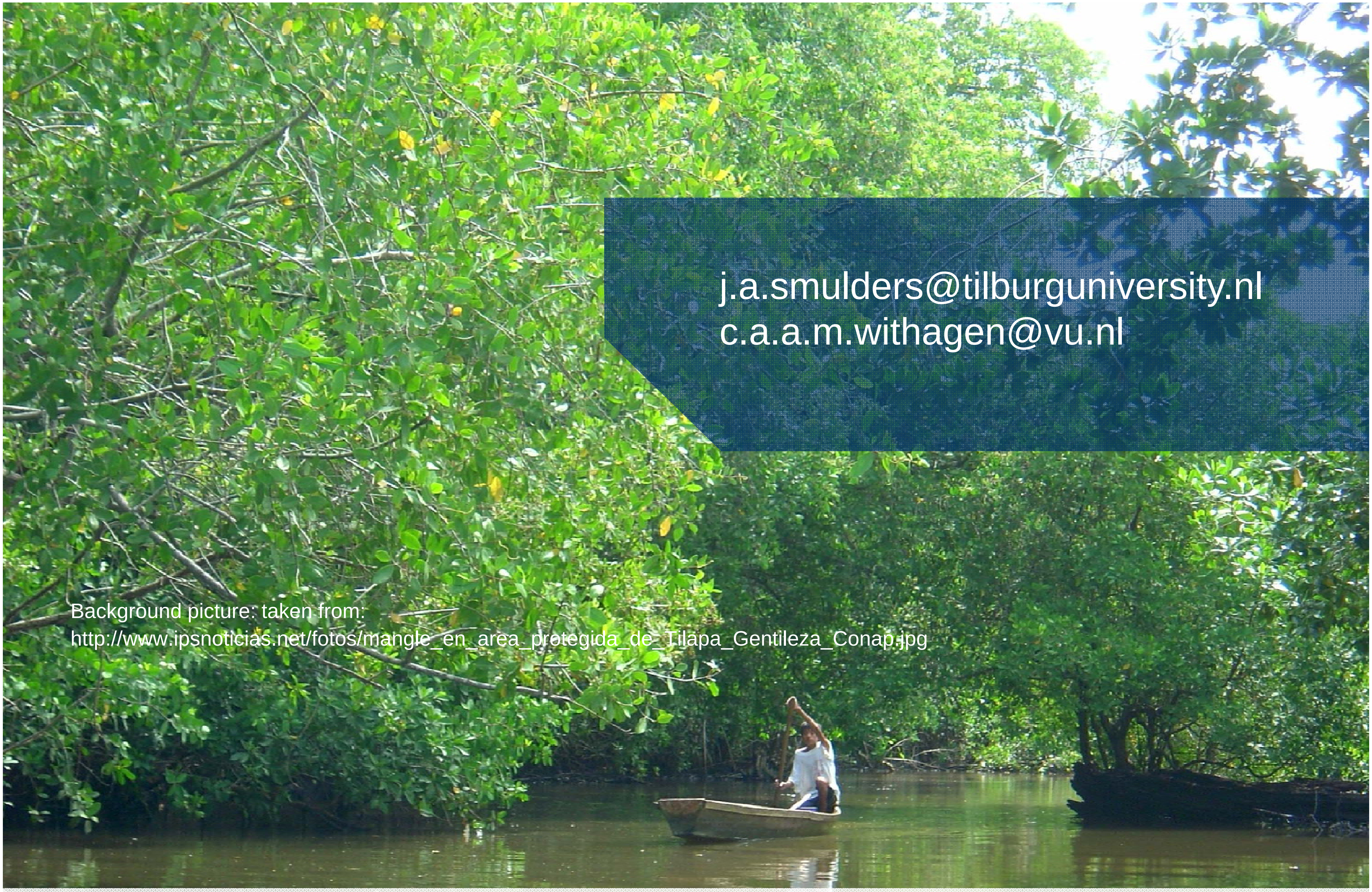

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