6-2019

Indonesia, Forest Fires, Haze, Height: Case for Planetary Health Economics - June 2019

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Indonesia, forest fires, haze, height:
Case for planetary health economics

Subhrendu K Pattanayak (Duke University)
subhrendukp || @SETIenergy

Forest Collaboratorive EfD, 25 June 2019
(drawing on National Academies
& many cookstove talks)

Escalating human pressure on global environment

Environmental changes and ecosystem impairment	Examples of health impacts
Climate change Stratospheric ozone depletion Forest clearance and land-cover change	**Direct health impacts** Floods, heatwaves, water shortage, landslides, increased exposure to ultraviolet radiation, exposure to pollutants
Land degradation and desertification Wetlands loss and damage Biodiversity loss	**'Ecosystem-mediated' health impacts** Altered infectious diseases risk, reduced food yields (malnutrition, stunting) depletion of natural medicines, mental health (personal, community), impacts of aesthetic/cultural impoverishment
Freshwater depletion and contamination Urbanisation and its impacts Damage to coastal reefs and ecosystems	**Indirect, deferred, and displaced health impacts** Diverse health consequences of livelihood loss, population displacement (including slum dwelling), conflict, inappropriate adaptation and mitigation

1. Ecosystems and Human Health


CHAPTER 4

Through the looking glass: Environmental health economics in low and middle income countries*

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Photo credits: CIFOR

Example 1: Indonesia (forest fires, haze)

PNAS

COLLOQUIUM PAPER

Seeking natural capital projects: Forest fires, haze, and early-life exposure in Indonesia

Jie-Sheng Tan-Soo[a] and Subhrendu K. Pattanayak[b,c,1]

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Edited by S. Polasky, University of Minnesota, St. Paul, MN, and approved January 15, 2019 (received for review March 26, 2018)

Natural capital will be depleted rapidly and excessively if the long-term, offsite impacts of depletion are ignored. By examining the case of tropical forest burning, we illustrate such myopia: Pursuit of short-term economic gains results in air pollution that causes long-term, irreversible health impacts. We integrate longitudinal data on prenatal exposure to the 1997 Indonesian forest fires with child nutritional outcomes and find that mean exposure to air pollution during the prenatal stage is associated with a half-SD decrease in height-for-age *z* score at age 17, which is robust to several statistical checks. Because adult height is associated with income, this implies a loss of 4% of average monthly wages for approximately one million Indonesian workers born during this period. To put these human capital losses in the context of policy making, we conduct social cost–benefit analyses of oil palm plantations under different scenarios for clearing land and controlling fires. We find that clearing for oil palm plantations using mechanical methods generates higher social net benefits compared with clearing using fires. Oil palm producers, however, would be unwilling to bear the higher private costs of mechanical clearing. Therefore, we need more effective fire bans, fire suppression, and moratoriums on oil palm in Indonesia to protect natural and human capital, and increase social welfare.

sustainable development | environmental health | oil palm | cost–benefit analysis | health irreversibility

unfortunately, such forest fires have become even more frequent lately, including a round of devastating forest fires in 2015. Despite their magnitude and frequency, we know surprisingly little about the full social costs of these fires. While there is evidence on short-run health damages of air pollution, little is known about the long-term and intergenerational costs of early-life exposure to air pollution.

Most studies of early-life exposure to air pollution are conducted in high- or middle-income countries and focus on immediate birth outcomes (16, 17). From past analyses, there is strong evidence showing that early-life exposure to air pollutants is associated with low birthweight and preterm birth (16, 17). The suspected pathways from air pollutants to birth outcomes are inflammation and direct toxic effects to the placenta and fetus, oxygen supply to the fetus, and DNA expression (17). With respect to longer-term outcomes, the literature on the "fetal origins" hypothesis suggests that intrauterine health insults can cause lasting and irreversible damage to cardiovascular and respiratory health and that low birthweight is associated with shorter height in adulthood (18–21). Still, there are very few studies that specifically make the connection between environmental exposure to air pollutants at early-life and long-term outcomes (22).

Demonstrating that a short-term episode of extremely high air pollution has long-term health impacts is salient to many low- and

SUSTAINABILITY SCIENCE

Press, News Cycle, etc.

INDONESIAN FIRES ROBBED KIDS OF HEIGHT AND FUTURE INCOME

FEBRUARY 21ST, 2019

POSTED BY DUKE UNIVERSITY

Indonesia forest fires stunt child growth: study

By **Taylor McDonald** - 2019-02-25

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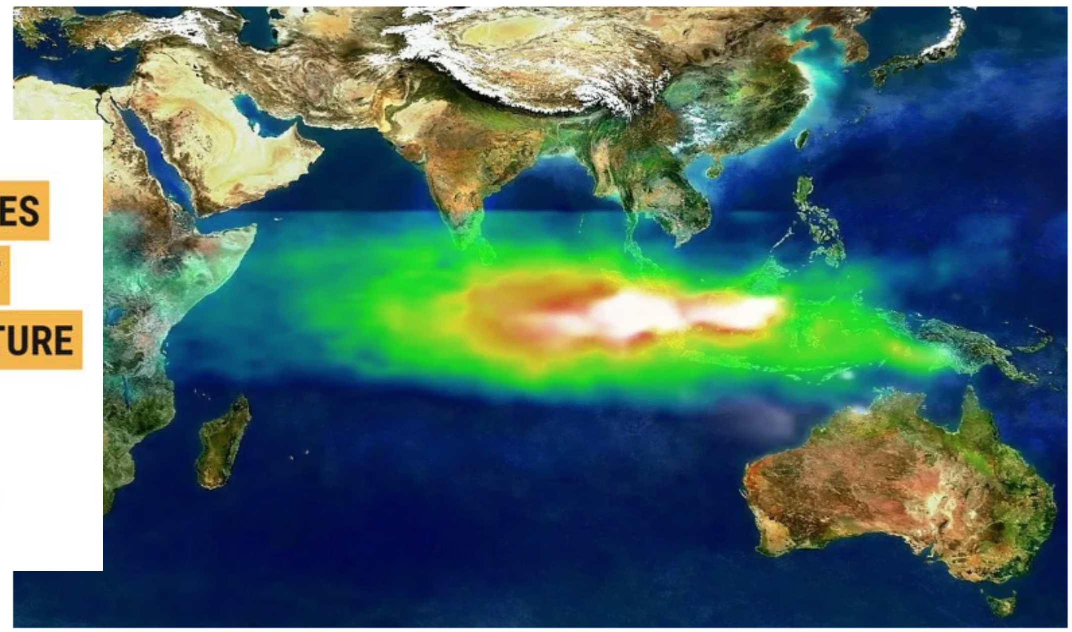


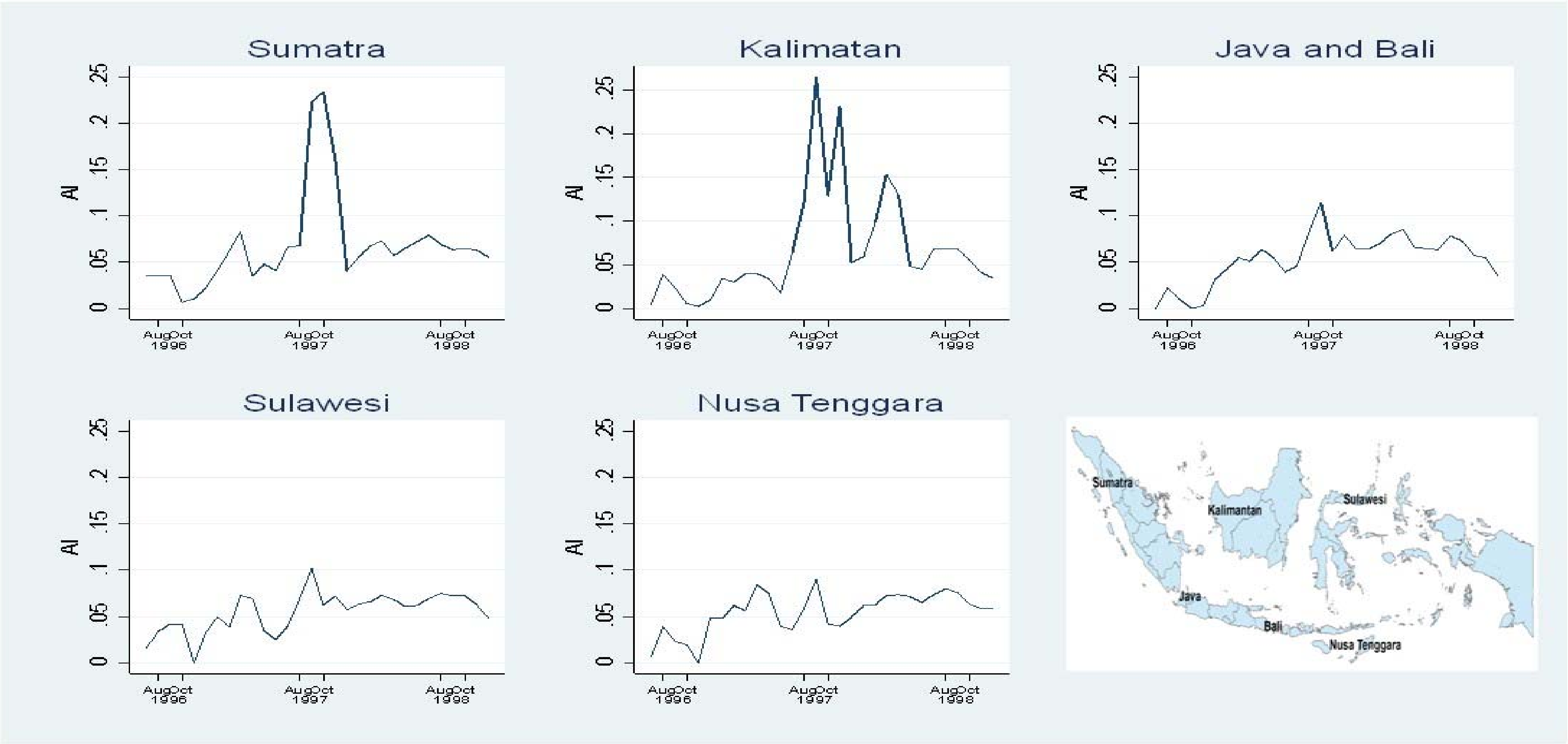
Better Data, Harder Work

- Indonesian Family and Life Surveys
  - Representative of about 80% of Indonesia
  - 1997 (Household locations and characteristics)
  - Outcome: Height – because (1) indicative of earning potential, (2) less susceptible to contemporaneous conditions, unlike weight or lung function
  - Relatively easier to measure, compared to cognitive ability or school grades
  - 2000 (Height at ~3 years old), 2007 (Height at ~10 years old), 2014 (Height at ~17 years old)
- Air quality
  - Satellite-derived Aerosol Index ("AI")
  - Proxy for air quality due to lack of ground stations
- Climate (Temperature and Rainfall)
  - Additional environmental controls (Maccini & Yang, 2009)

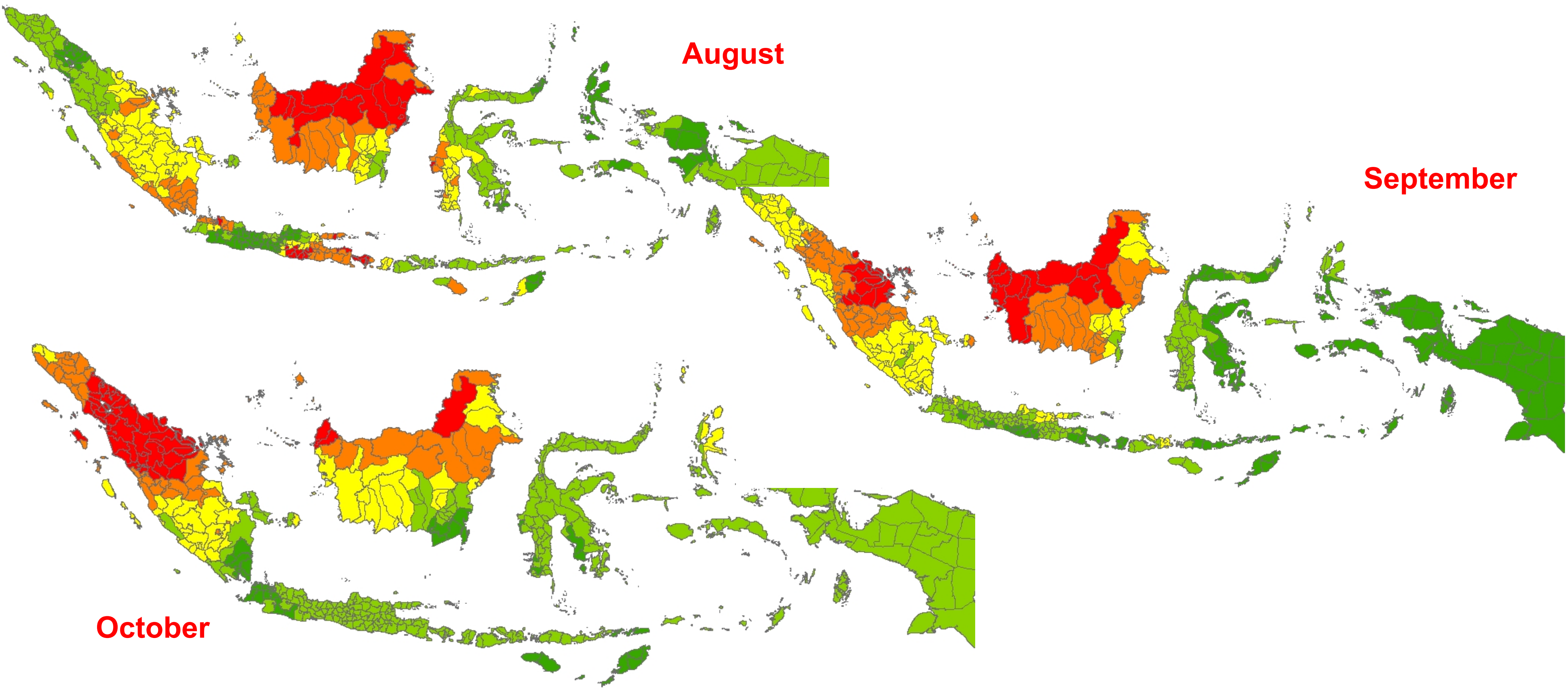
3. Better Methods: Experimental, Quasi Experimental

- Use the 1997 fires as a 'shock' event
  - Similar strategy in Frankenberg, McKee, & Thomas (2005) and Jayachandran (2009)
  - Prior to 1997, major forest fires were quite irregular in Indonesia
  - After 1997, much more frequent
- From the survey data, pick out those there are either in pre-natal or first 6 months of their lives (Prendergast & Humphrey, 2014) during August 1997 to October 1997
  - Spatial variation: Pollution were heavier in some places than others due to location of forests and wind directions
  - Temporal variation: Timing of birth
  - About 550 individuals

Spatial-temporal variation in AI Exposure of Pregnant Mothers



Spatial-temporal variation in AI Exposure of Pregnant Mothers



Estimating equations

Main:

$$y_{ijkt} = \beta_0 + \beta_1 AI_{ijt} + \beta_2 AI_{ijt} \cdot I(y_{2000}) + \beta_3 AI_{ijt} \cdot I(y_{2007}) + I(y_{2000}) + I(y_{2007}) + X_i\gamma + \delta_j + \alpha_m + \varepsilon_{ijt}$$

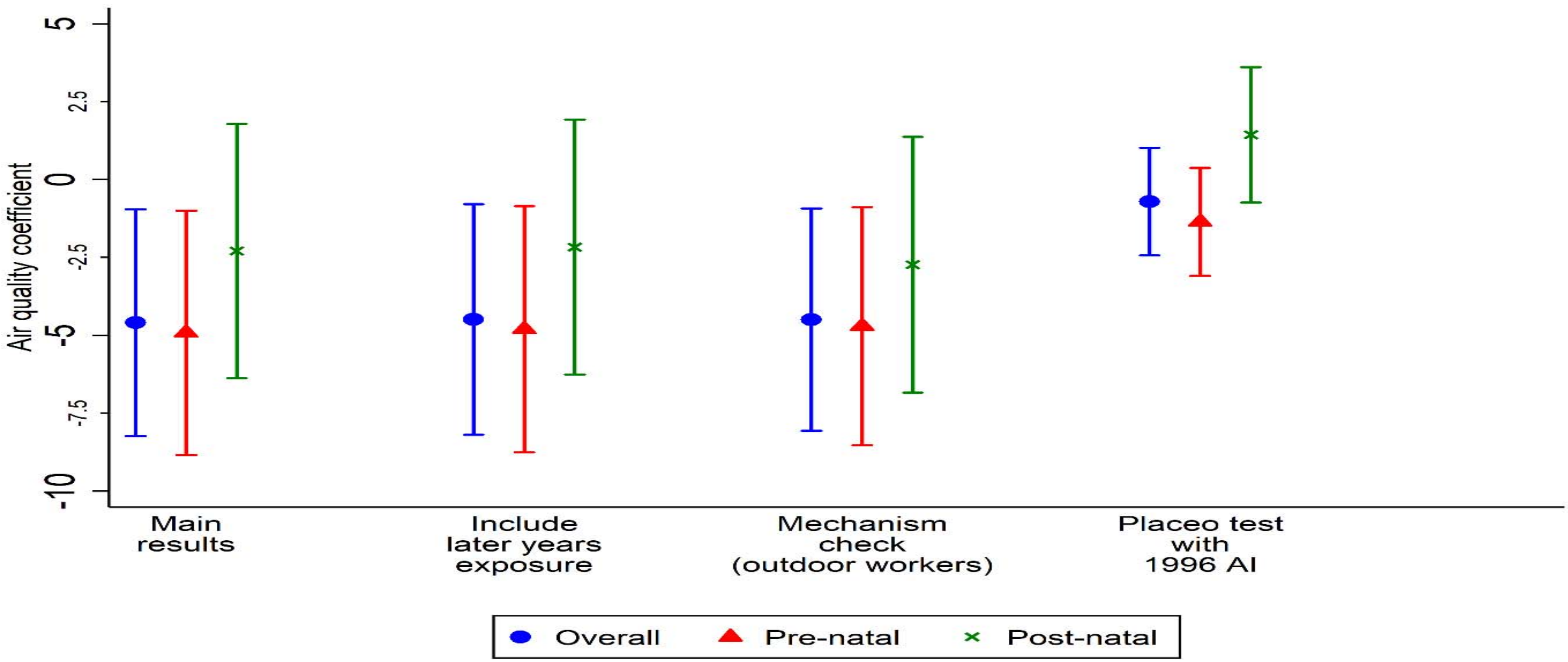
Split into prenatal and post-natal:

$$y_{ijkt} = \beta_0 + \beta_1 preAI_{ijt} + \beta_2 postAI_{ijt} + \beta_3 preAI_{ijt} \cdot I(y_{2000}) + \beta_4 preAI_{ijt} \cdot I(y_{2007}) + \beta_5 postAI_{ijt} \cdot I(y_{2000}) + \beta_6 postAI_{ijt} \cdot I(y_{2007}) + I(y_{2000}) + I(y_{2007}) + X_i\gamma + \delta_j + \alpha_m + \varepsilon_{ijt}$$

Better Methods: Robustness checks …

1. What if regions had more air pollution in later years?
   - Include AI from 1998 and 1999 to examine if latter-years air pollution can also explain for height difference
2. What if something about regions? (beyond district fixed effects)
   - ‘Placebo’ test – assign the wrong dosage by using AI exposure from exactly one year ago
3. What if AI impacted work of family most engaged in outside work?
   - AI x family members are engaged in outdoor work
4. What if AI directly impacted incomes of households?
   - Did consumption decrease after forest fires?

Key Results (summary)



Air quality is proxied by aerosol index - a unitless construct that ranges from 0.01 (clear sky) to 0.4 (unable to see mid-day sun)

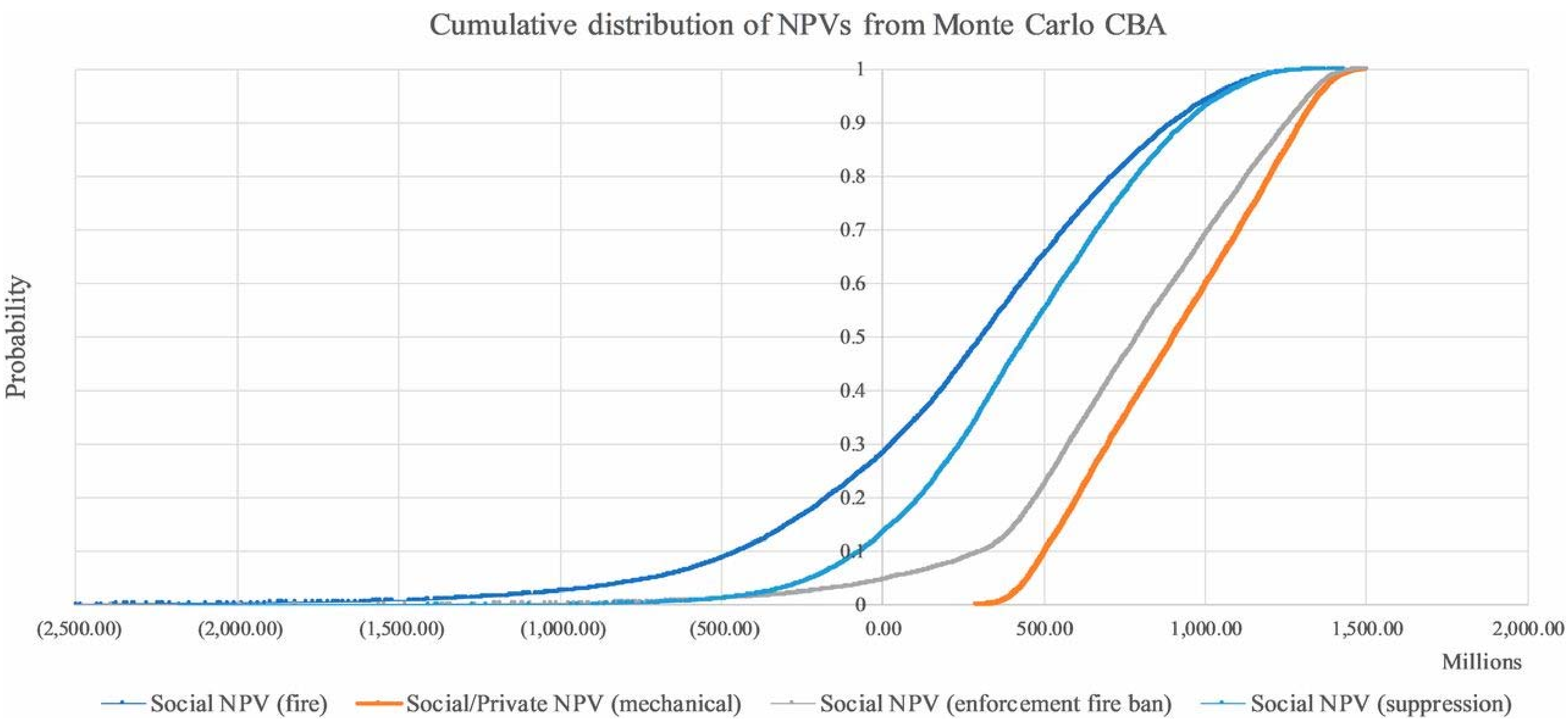
Cost-Benefit Analysis: what to do about fires & oil palm

- put these estimates, we conduct a CBA
  - benefits to health (both avoided losses in income and in mortality), tourism, and transportation
  - costs to firms (land preparation) and to agencies for program implementation
  - acknowledge & model the heterogeneity and uncertainty inherent in the parameters by conducting Monte Carlo simulations
- 3 scenarios (compared to BAU)
  - mechanical (non-fire) land clearing
  - stronger enforcement of ban
  - early detection & suppression

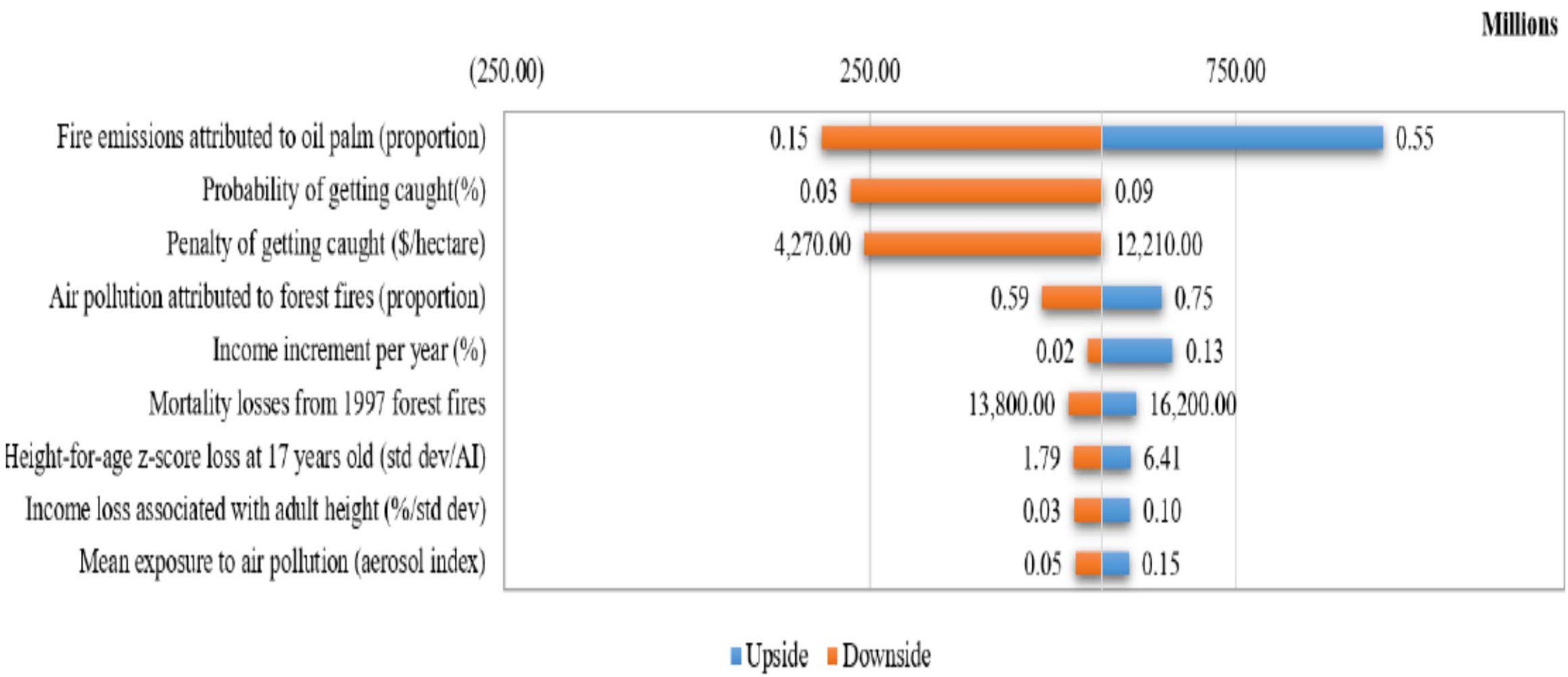
Beyond Impacts: Details of costs & benefits

Private firm profits	Revenue of oil-palm plantations – Costs of plantations (land clearing, set-up, maintenance)
Net social benefits	Avoided health costs (mortality, morbidity) + avoided non-health costs (tourism, transportation) – private firm profits
Net social benefits (suppression policy)	Avoided health costs (mortality, morbidity) + avoided non-health costs (tourism, transportation) – private firm profits – Program costs
Net social benefits (enforcement policy)	Avoided health costs (mortality, morbidity) + avoided non-health costs (tourism, transportation) – private firm profits – Program costs
Individual components (Costs/benefits)	**Equations**
Land clearing cost (mechanical)	$(Clear_{Mech} + Eco) \cdot OP$
Land clearing cost (fire)	$(Clear_{Fire}) \cdot OP$
Setup cost (mechanical)	$\frac{OP}{years} \cdot SP_m \left[\left(1 - \left(\frac{1}{1-DR}\right)\right) \Big/ \left(1 - \left(\frac{1}{1-DR}\right)^{years}\right) \right]$
Setup cost (fire)	$\frac{OP}{years} \cdot SP_f \left[\left(1 - \left(\frac{1}{1-DR}\right)\right) \Big/ \left(1 - \left(\frac{1}{1-DR}\right)^{years}\right) \right]$
Mortality cost	$AP_{FF} \cdot FFE_{OP} \cdot VSL \cdot Mort$
Loss-of-income	$AP_{FF} \cdot FFE_{OP} \cdot Born \cdot HAZ_{AI} \cdot AI \cdot \left[\left(\sum_{t=21}^{35} \frac{Wage \cdot (1+Inc)^{t-21}}{(1+DR)^t} \right) + \left(\sum_{t=36}^{58} \frac{Wage \cdot (1+Inc)^{15}}{(1+DR)^t} \right) \right]$
Tourism	$AP_{FF} \cdot FFE_{OP} \cdot Tour$
Transportation	$AP_{FF} \cdot FFE_{OP} \cdot Tp$
Annual cost of early-fire detection	$EF \cdot \left[\left(1 - \left(\frac{1}{1-DR}\right)\right) \Big/ \left(1 - \left(\frac{1}{1-DR}\right)^{life}\right) \right]$
Proportion reduction in using fires in response to enforcement	$1 - risk^{\frac{(cgt*pen)}{(Clear_{Mech}+Eco-Clear_{Fire})}} \cdot \left(1 - \frac{(cgt*pen)}{(Clear_{Mech}+Eco-Clear_{Fire})}\right)$

Beyond Impacts: Social NPV of different policy scenarios



Beyond Impacts: 1-way sensitivity analysis



Twitter Takeaways: II

Subhrendu Pattanayak
@subhrendukp

forestfires for oilpalm causes stunting, socially better alternatives exist; better data, harder work @randall_kramer @beckyck @DukeGHI @arjendu @gotonura, @william_c_clark @ph_alliance @TheLancetPlanet @naturesustainab

Seeking natural capital projects: Forest fires, haze,...
Natural capital will be depleted rapidly and excessively if the long-term, offsite impacts of depletion are ignored. By examining the case of tropical forest burning, we il...
pnas.org

Twitter Takeaways: II

Subhrendu Pattanayak @subhrendukp · Feb 19
1/n one of the first studies of the lagged impacts of early-life exposures to air pollution, using data from Indonesia, a middle-income country critical to global conservation

1 2

Subhrendu Pattanayak @subhrendukp · Feb 19
2/n analyses of planetary health policies—which are multisectoral and interdisciplinary in nature—require methodologically flexible approaches; so we first estimate the haze-height effect by applying rigorous quasi-experimental methods on a multisectoral dataset

1 1

Subhrendu Pattanayak @subhrendukp · Feb 19
3/n Next, we use these impact estimates in a CBA of various policy solutions to the haze problem. Specifically, we use Monte Carlo simulations to account for the heterogeneity and uncertainty associated with the many costs and benefits

1 1

Subhrendu Pattanayak @subhrendukp · Feb 19
4/n this combination of estimation and simulation illustrates an applied research framework (e.g., @NatCapProject) that can be used to mainstream conservation science into the decision making by communities, companies, governments, and donors

1

Subhrendu Pattanayak @subhrendukp · Feb 19
5/n following calls from implementation science research, we attempt to provide approximate, if imperfect, practical advice that policy makers seek, instead of stopping at precise (and sometimes irrelevant) estimates

1 1

Subhrendu Pattanayak @subhrendukp · Feb 19
6/n because social NPV of fire suppression, fire bans depend on factors that vary by location (e.g., emissions attributed to oil palm, local income growth), targeting will be efficient; findings provide strong justification for ongoing Indonesian government policies

Getting old … & hoping learning some lessons

ARTICLE

Deforestati… research to…

Subhrendu Pattana… Kramer[2]
[1] Public Health and Env… (email: subhrendu@…
[2] Nicholas
[3] The Cent
[4] Nicholas
[5] Departme

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Biodive…
DOI 10.…
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Public health impacts of ecosystem change in the Brazilian Amazon

Simone C. Bauch[a], Anna M. Birkenbach[b], Subhrendu K. Pattanayak[b,c,1], and Erin O. Sills[d,e]

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Edited by Stephen Polasky, University of Minnesota, St. Paul, MN, and approved November 13, 2014 (received for review May 10, 2014)

The claim that nature delivers health benefits rests on a thin empirical evidence base. Even less evidence exists on how spe… policies affect multiple health outcomes. We addr… knowledge by combining municipal-level panel … public health services, climatic factors, demograp… policies, and other drivers of land-use change in the … To fully exploit this dataset, we estimate random-ef… regression models of disease incidence. We find t… respiratory infection (ARI), and diarrhea incidence … and negatively correlated with the area under str… protection. Results vary by disease for other types … (PAs), roads, and mining. The relationships betw… land-use change drivers also vary by quantile of th… tion. Conservation scenarios based on estimated … suggest that malaria, ARI, and diarrhea incidence … by expanding strict PAs, and malaria could be fu… restricting roads and mining. Although these relat… plex, we conclude that interventions to preserve na… deliver cobenefits by also increasing human (h…

large environmental component and disproportionate impact on …

Nature's care: diarrhea, water and biodiversity conservation i…

Subhrendu K. Pattanayak · Kelly J. Wen…

PHILOSOPHICAL TRANSACTIONS B

rstb.royalsocietypublishing.org

Opinion piece

Cite this article: Pattanayak SK, Kramer RA, Vincent JR. 2017 Ecosystem change and human health: implementation economics and policy. *Phil. Trans. R. Soc. B* 372: 20160130.
http://dx.doi.org/10.1098/rstb.2016.0130

Accepted: 30 August 2016

One contribution of 13 to a theme issue 'Conservation, biodiversity and infectious disease: scientific evidence and policy implications'.

Subject Areas:
health and disease and epidemiology, environmental science

Ecosystem change and human health: implementation economics and policy

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Several recent initiatives such as *Planetary Health*, *EcoHealth* and *One Health* claim that human health depends on flourishing natural ecosystems. However, little has been said about the operational and implementation challenges of health-oriented conservation actions on the ground. We contend that ecological–epidemiological research must be complemented by a form of implementation science that examines: (i) the links between specific conservation actions and the resulting ecological changes, and (ii) how this ecological change impacts human health and well-being, when human behaviours are considered. Drawing on the policy evaluation tradition in public economics, first, we present three examples of recent social science research on conservation interventions that affect human health. These examples are from low- and middle-income countries in the tropics and subtropics. Second, drawing on these examples, we present three propositions related to impact evaluation and non-market valuation that can help guide future multidisciplinary research on conservation and human health. Research guided by these propositions will allow stakeholders to determine how ecosystem-mediated strategies for health promotion compare with more conventional biomedical prevention and treatment strategies for safeguarding health.

This article is part of the themed issue 'Conservation, biodiversity and infectious disease: scientific evidence and policy implications'.

…s?
…ndia

…sanitation in rural India. …s in 242 villages located …and-driven water supply …ents of coping and illness

Subhrendu K. Pattanayak* · Martin T. Ross† · Simone C. Bauch** · Christopher Tim… · Kelly J. Wendland‡‡ · Keith Alge…

Article history:
Received 15 May 2010
Received in revised form 13 August 2010
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Keywords:
Environmental health
Malaria

Despite the potential for economic growth, extractive mineral industries can impose negative health externalities in mining communities. We estimate the size of these externalities by combining household interviews with mine location and estimating statistical functions of respiratory illness and malaria among villagers living along a gradient of proximity to iron-ore mines in rural India. Two-stage regression modeling with cluster corrections suggests that villagers living closer to mines had higher respiratory illness and malaria-related workday loss, but the evidence for mine workers is mixed. These findings contribute to the thin empirical literature on environmental justice and public health in developing countries.

Biodiversity Loss Affects Global Disease Ecology

MONTIRA J. PONGSIRI, JOE ROMAN, VANESSA O. EZENWA, TONY L. GOLDBERG, HILLEL S. KOREN, …

Implementation of policies to protect planetary health

Extensive evidence exists that human health and civilisation depends on flourishing natural systems.[1] The Rockefeller-Lancet Commission on planetary health summarised how climate change, biodiversity loss, freshwater depletion, and air and water pollution threaten to reverse advances in human health and increase health inequities worldwide.[2] For example, increasing carbon dioxide concentrations and declines in animal pollinators will exacerbate micronutrient deficiencies and risks of non-communicable disease.[3] These examples reinforce the growing concerns that environmental degradation could cause rapid and irreversible damage to the natural systems underpinning human civilisation in ways that cannot be effectively addressed by biomedical advances alone. The Sustainable Development Goals now provide an important opportunity to confront these challenges. Because planetary health efforts integrate sustainable development, environmental conservation, and health equity, they can provide an overarching framework for developing policies for and monitoring progress towards … on policy implementation is insufficient, we have learnt little about why innovations and interventions fail.

One plausible reason for the inadequate progress is that evidence from high-income settings cannot be directly transposed to low-income or middle-income settings where barriers and facilitators are different. This inability to transpose evidence occurs because implementation challenges are less about puzzles in engineering, epidemiology, and environmental science, and more about the incentives, barriers, and institutions on the ground. Furthermore, implementation barriers for planetary health are very different from those encountered when biomedical and health-care interventions are implemented. In the case of planetary health, more complex causal chains in time and space are implicated with multiple stakeholders. Consider four perspectives. First, compared with John Snow's conclusion that disablement of the handle of the public water pump on Broad Street could arrest the cholera outbreak in London, contemporary planetary health problems are

…ultural Household Response to Avian Influenza Prevention and Control Policies

Robert H. Beach, Christine Poulos, and Subhrendu K. Pattanayak

Recent outbreaks of highly pathogenic avian influenza in Asia, Europe, and Africa have caused severe impacts on the poultry sector through bird mortality and culling, as well as resulting trade restrictions and negative demand shocks. Although poultry producers play a major role in preventing and controlling avian influenza, little research has examined the influence of their farm-level decision making on the spread of the disease. In this study, we describe an economic model of farms facing avian influenza risks and discuss data and analyses necessary to generate sound empirical evidence to inform public avian influenza prevention and control measures.

Achieving Planetary Health & Avoiding Type 3 Erros

- Avoid rat race with environmental epidemiologists on identification
  - Unless arguing strongly for behavioral (hh & policy) confounders
- Instead, bring science to implementation
  - Implementation barriers an afterthought, and thoroughly neglected (*Lancet Planetary Health* 1(7):e255-256)
  - Multi-disciplinary research from the frontiers of impact evaluation & non-market valuation (*Philosophical Transactions Royal Society B* 372 (1722) 20160130)
- 4 principles (… with Polasky, Ferraro, Reyer, Sills)
  - mainstream science into decision-making
  - map & measure entire evidence chains from actions by government, business, and civil society, to ecosystem impacts, and then to human health and wellbeing
  - seek appropriate study designs for suite of benefits and cost measurements
  - embrace frameworks that include uncertainty

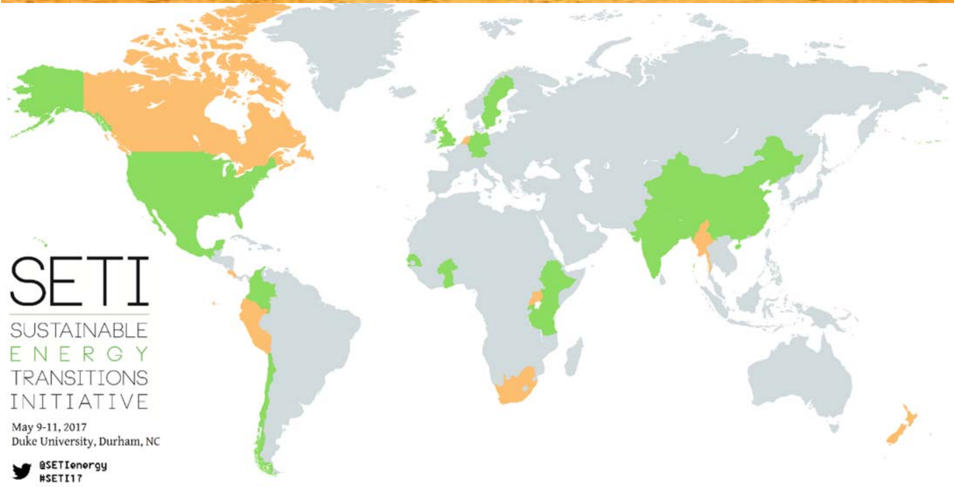
Or … https://t.co/NVLVzv8Hxl (my rare YouTube moment)

No one says this is going to be easy

Conve

Sustainable Energy Transitions Initiative

- State of knowledge
- Coordinated research
- Community of practice
- Policy support



Example 2: India (indoor air pollution)

Experimental evidence on promotion of electric and improved biomass cookstoves

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Edited by William C. Clark, Harvard University, Cambridge, MA, and approved April 22, 2019 (received for review May 25, 2018)

Improved cookstoves (ICS) can deliver "triple wins" by improving household health, local environments, and global climate. Yet their potential is in doubt because of low and slow diffusion, likely because of constraints imposed by differences in culture, geography, institutions, and missing markets. We offer insights about this challenge based on a multiyear, multiphase study with nearly 1,000 households in the Indian Himalayas. In phase I, we combined desk reviews, simulations, and focus groups to diagnose barriers to ICS adoption. In phase II, we implemented a set of pilots to simulate a mature market and designed an intervention that upgraded the supply chain (combining marketing and home delivery), provided rebates and financing to lower income and liquidity constraints, and allowed households a choice among ICS. In phase III, we used findings from these pilots to implement a field experiment to rigorously test whether this combination of upgraded supply and demand promotion stimulates adoption. The experiment showed that, compared with zero purchase in control villages, over half of intervention households bought an ICS, although demand was highly price-sensitive. Demand was at least twice as high for electric stoves relative to biomass ICS. Even among households that received a negligible price discount, the upgraded supply chain alone induced a 28 percentage-point increase in ICS ownership. Although the bundled intervention is resource-intensive, the full costs are lower than the social benefits of ICS promotion. Our findings suggest that market analysis, robust supply chains, and price discounts are critical for ICS diffusion.

improved cookstoves | technology adoption | Indian Himalayas | supply chain | price subsidies

ducting a multiyear, multiphase study in the Indian Himalayas. Phase I started with a series of diagnostic steps (spanning 18 mo) to uncover the nature of low ICS adoption. In phase II, we implemented a set of pilots to simulate a mature market and designed an intervention that would reduce both supply and demand constraints. Finally, in phase III, we experimentally tested a package of interventions, spanning an additional 18 mo, in a sample of ∼1,000 households living in nearly 100 rural Himalayan communities. Our principal hypothesis, derived from insights gleaned from the diagnosis and design phases, was that ICS demand would be highly sensitive to a multipronged intervention combining (*i*) a well-developed technology supply ecosystem (characterized by delivery, demonstration, promotion, and financing) with (*ii*) demand-stimulating subsidies. Additionally, our second hypothesis was that the well-developed supply chain alone would lead to considerable ICS adoption; that is, one of the treatment arms of our randomized

Significance

Three billion people rely on traditional stoves and solid fuels. These energy use patterns exacerbate the global climate crisis (via increased carbon emissions) and forest degradation/deforestation (via daily fuelwood collection), and expose billions to toxic air pollution generated by dirty fuels. Widespread adoption of improved cookstoves (which use cleaner fuels or burn solid fuels more efficiently) may ease this "triple burden," but recent research casts doubt on their potential, given low and slow diffusion. We challenge this pessimism based on a multiyear, three-phase field study com-

SUSTAINABILITY SCIENCE

Result1. large purchase response

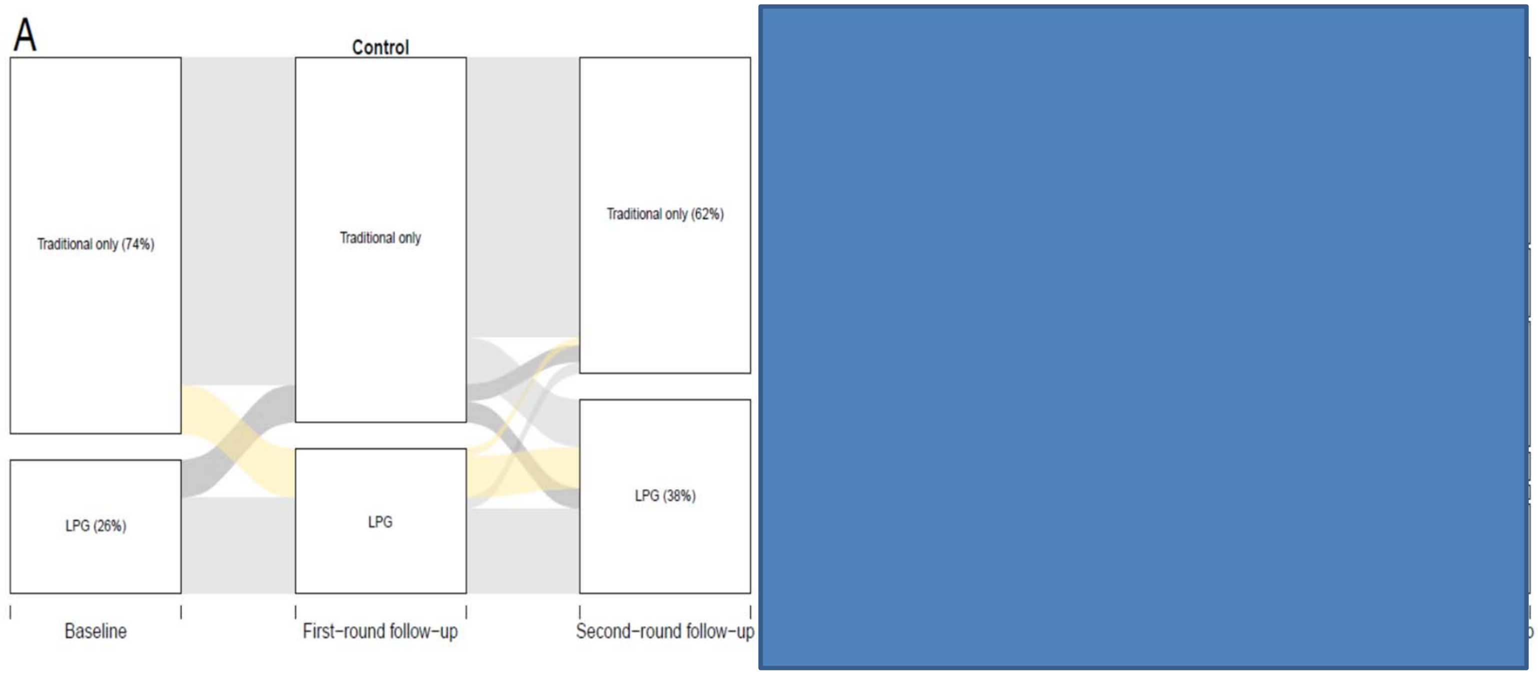

Fig. 3. Stove ownership over time by treatment group: control (*A*) and treatment (*B*). Baseline surveys occurred in summer 2012. Intervention occurred in summer 2013. First-round follow-up surveys occurred 3 mo after the intervention. Second-round follow-up occurred ∼15 mo after the intervention.

4 of 6 | www.pnas.org/cgi/doi/10.1073/pnas.1808827116 Pattanayak et al.

Possible to achieve high ownership and use in low income settings!