ASB BNPP Policybriefs (first rough drafts, not for quotation)

1 Hypotheses for Policy Briefs (Tom)

Null Hypothesis 1. Land cover change has no significant effect on specific watershed functions (viz., total yield, flooding, sedimentation, landslides, dry season flow) beyond (a small scale to be specified at this meeting).

Null Hypothesis 2. Land cover change upstream has no significant effect on people downstream in large basins.

Null Hypothesis 3. Land cover change has no significant effect on people in small watersheds / sub catchments.

Null Hypothesis 4. There is no significant spatial coincidence between globally significant habitats and key watershed management areas.

Null Hypothesis 5. There is no significant spatial coincidence between globally significant habitats and rural populations in the tropics.

2 Template for first ASB BNPP Policybrief *(first rough draft, not for quotation)*

2.1 Working title: Rainforests matter for water

2.2 Highlights

Water worries (rainfall as non-issue re land cover change; cloud forests are exceptions)

2.2.1 Localized effects

(land cover and total water yield; flooding, siltation, land slides; dry season flow; water quality)

2.2.2 Long distance connections

(land cover and total water yield; dry season flow?; water quality; not flooding, siltation, land slides)

2.2.3 Focusing policy concern

Sidebar ('strawman'): Conventional wisdom has it that tropical forests play an indispensable role in rainfall and the quantity and purity of water supply for agriculture, industry, and urban populations. Similarly few doubt direct causal links between deforestation and flooding far downstream. A revision of these long-held views – backed by scientific evidence – indicates tropical forest cover has much less effect on climate and water supply than we once thought. And flooding risk is determined more by lowland land use change, including loss of wetlands, and patterns of urbanization in developing countries, rather than deforestation upstream. Can policymakers relax? No, but they need to refocus on real problems.

Lead: RAINFORESTS AND WATER SUPPLIES are linked, but new scientific results are causing a revolutionary rethink of tropical hydrology.

Page 1 image: landscape photo of cloud forest; caption on cloud forests as influential of people's thinking but exceptional in reality

Other images or text boxes (assuming a 4-page format):

Figure: 3-d image of Central American watershed prepared by Andy for 1st project review

Table or figure (devised by Meine?) showing (or recast as problems) to definitively answer **our primary question: which watershed functions (and at what scale) are most threatened by land cover change?** Secondarily: Does this depend on topographic/geographic context? If so, how?

Watershed function (or recast as a problem)	Importance (example)	Scale of effect arising from land cover change / deforestation (topographic and or geographic context?)
Quantity and timing of water supply		
- dependable (high) total water yield	Filling lakes and reservoirs	Long-distance / basin wide
- high dry season flow	Dry season water supply if no storage facilities	Local and long-distance ????
- low peak flow	Reduce flooding risk in lowlands	How to determine conclusively?
Little soil movement		
- low sediment load in stream	Reservoir life	Sediment delivery ration X area
- few landslides/mudflows	Safety in valley villages	Local
Good water quality		
- drinking water	Direct source for domestic use	???
- fish and other biota	Fishers; biodiversity conservation	???
- 'cool' water (???)	Ricefields (in N. Thailand)	Local
- Avoid salinization	Relevant in humid tropics?	???
- Groundwater recharge	Relevant???	Distance X time issues

Source: ASB Lecture Note 7 (Susswein and van Noordwijk) p. 9

Note: with specific reference to humid tropics; these need not hold for other contexts

Also see: Table 3 p. 13 of van Noordwijk, Ranieri, and Tomich. Relating watershed functions to the main inputs that have to be incorporated as 'drivers' in predictive models

2.3 'For more information' (ie. this is where the results come from):

NB. ASB Lecture Note 7 'Forest Watershed Functions and Tropical Land Use Change' by PM Susswein and M van Noordwijk is an excellent starting point for the text of this policybrief.

Activities/deliverables related to Null Hypothesis 1. Land cover change has no significant effect on specific watershed functions (viz., total yield, flooding, sedimentation, landslides, dry season flow) beyond (a small scale to be specified at this meeting).

Manuscript deliverable 4(b) corresponding to Activity 2–see master contract—on relationship among land use change, biodiversity, and hydrological functions in small and medium basins, with particular reference to MMSEA.

ACTIVITY 2. Phase II activities of ICRAF Bogor and Chiang Mai with Uof W. Work reported for Phase I showed that the relevant scale of effects vary by hydrological function – total yield, dry-season flow, flood regulation, groundwater recharge, sediment load, landslide risk, water quality – and that no single model can be used to analyze the complete range of these policy-relevant watershed functions across all scales. Phase II work under Activity 2 will produce deeper understanding of the scope and limits of the various techniques for specific watershed functions, particularly investigating the relevance of fine-scale, process-based insights for larger reporting scales that are relevant to policymakers. Key questions to be resolved are:

What is the adaptability of various modeling strategies to different scales and resolution levels?

At what size of watershed - 10 km2, 1000 km2, 10000 km2 - are different hydrological effects of land cover change salient?

How do different land use mosaics interact with physical determinants of hydrology and, thereby, affect vulnerability of human populations?

Specific tasks and responsibilities of UW under Activity 2

Assemble the dataframe required for the application of the VIC hydrology model to the Mekong river drainage basin (and Mae Chaem/Ping, and conceivably to Chao Phrya).

Assemble the dataframe required for the application of the DHSVM model to the Mae Chaem (insert basin of interest here) river basin.

Provide model simulations on both dataframes (using the respective model) over a standard climatology and either a "standard" rainfall, or a "typical actual rainfall record" (ie. last 10 years).

Produce modeled output with landcover alterations of forested landscapes at various degrees and in different upland and floodplain configuration so as to simulate a range of landuse change scenarios.

Report the results of all model simulations in terms of:

total yield by time at locations upstream from major urban centers and at the coastal zone,

seasonal variability of total flow related to seasonality of the simulated rainfall data,

duration of storm events effects on stage height at location upstream from major urban centers.

U of W deliverables under Activity 2

For each of the reported results listed above select subbasins at a variety of sizes and summarize the effect of basin scale on these modeled results. The purpose of this tasks is to identify a relationship between basin size and variation in the structure of the modeled hydrograph.

2.4 Other sources

UNH and UofW team websites

Bruijnzeel, LA (Sampurno). (forthcoming 2003) Tropical forests and environmental services: not seeing the soil for the trees? *Agriculture Ecosystems and Environme*nt (forthcoming 2003)

Calder, Ian. (2000) Land use impacts on water resources. Rome: FAO Land-water linkages in rural watersheds. *Background Paper No. 1.*

[Assuming that Bruijnzeel and Calder both will be technical reviewers and contributors.]

Chomitz KM and and Kumari K. 1998. The domestic benefits of forests: a critical review. *World Bank Research Observer* 13 (1): 13-35.

Chomitz KM and Nelson A. The forest-hydrology-poverty nexus in Central America: an heuristic analysis. (under review) van Noordwijk M, Ranieri S, and Tomich TP. (under review) Agroforestry, biodiversity and watershed functions of tropical land use mosaics" In G Schroth et al eds. *Agroforestry and Biological Conservation in Tropical Landscapes*

Ziegler AD, Giambelluca TW, Sutherland RA, Pongpayack Y, Yarnasarn S, Nullet MA, Pintong J, Vana T, Jaiaree S, and Boonchee S. Toward understanding the cumulative impacts of roads in agricultural watersheds of montane mainland Southeast Asia *Agriculture Ecosystems and Environme*nt (forthcoming 2003)

3 Template for second ASB BNPP Policybrief *(first rough draft, not for quotation)*

3.1 Working title: Deforestation and vulnerability in large river basins

Or: Deforestation of tropical watersheds and vulnerability of downstream populations

3.2 Highlights

Upstream-downstream connections *(picks up long distance effects where first BNPP brief left off)*

Weather and topography matter most for flooding *(does land cover matter at all?)*

Where the risks aren't *(across the tropics)*

Vulnerable populations *(#s of urban and lowland rural vs upland rural)*

3.3 Forest-hydrology-poverty nexus revisited

Sidebar ('strawman'): For good or ill, the quantity, quality, and timing of water supplies are key determinants of human welfare. Deficiencies in water supplies are a growing feature of poverty in the 21st Century. The biggest vulnerable groups are in the lowlands, especially in burgeoning cities of the tropics. These water problems and deficiencies have little to do with deforestation or land use upstream or with welfare of the people seeking their livelihoods in the forest margins.

Lead: HYDROLOGY MAKES HEADLINES whenever capital cities flood.

Page 1 image: photo of people coping in flooded streets of an Asian capital city

Other images or text boxes:

Tabulation 1: total human population of biome; then disaggregated urban, rural lowland, rural upland by IFPRI team. Also suggest reporting by continent and total.

or Tabulation 2: Tabulation 1 disaggregated by terrain / watershed typology. If this can be done, it would be extremely useful! Again suggest reporting by continent and total.

Additional tabulation (based on Tab 1 or Tab 3) of these human populations relative to (rural?) population of the humid tropics (total and by continent).

Note further split that may make sense is mainland from insular SE Asia; Congo Basin from other humid tropical Africa, and Central America from Amazon (and any other) Latin America.

Map 1: showing areas/bands of most rapid deforestation across the biome (extension of IFPRI Phase 1 work on 'identifying forest margins using existing coarse resolution data' and fire data)

and/or Map 2: showing deforestation (how far ahead? 2025?) under business as usual – ie projection of current rates of deforestation

Associated tabulation **to relate maps to scenarios for vulnerability assessment**

(scenarios are from our June meeting):

Natural state (entire area of biome forested)

Current state (from Map 1?)

Business as usual (from Map 2?)

Complete deforestation except for Amazon and Congo Basin (depending on time frame, this may not differ from 'business as usual')

Also suggest Map 1 and Map 2 incorporate **terrain/watershed typologies** (from UNH).

Map 3–the most important one in this brief—showing the hot spots of risk. Can we bring exposure / vulnerability of human populations into Map 3? These are separate exercises, question is whether to juxtapose or overlay. I think overlay would be most effective.

Question: stay pantropic, zoom in to Central America or MMSEA, or both? I'd like to see both.

Text box: headlines and quotes from newspapers asserting causal connection between urban flooding and deforestation

3.4 'For more information'

Activities/deliverables related to Null Hypothesis 2. Land cover change upsteam has no significant effect on people downstream in large basins.

Note: This brief is one of 3 fulfilling deliverable 5(c) – see master contract.

Manuscript deliverable 4(a) corresponding to Activity 1–see master contract—on delineation at the global scale areas and populations that are (or are not) at potential risk from the hydrological impacts of land use change in the study focus areas (the tropical rainforest biome); and the degree to which threat-posing land use change also impacts biodiversity. (on the later, see BNPP PB #4)

Activity 1.B. Tasks (led by IFPRI with UNH and support from van Noordwijk, ICRAF SEA)

Pantropic assessment of areas of hydrological disturbance and impact. This activity will greatly upgrade and extend prototype work undertaken in the Phase I Pantropic analysis, drawing on the improved data sources and on the results of the synoptic modeling exercise of Activity 1.A. It consists of three components:

Characterize areas vulnerable to changes in hydrological function (e.g., flooding). Based on the results of 1A, this subactivity will assess the population, biodiversity, and other characteristics (e.g. dams, irrigation canals, reservoirs)of downslope/downstream areas facing different kinds of hydrological risks from different land use change scenarios.

Identify 'hydrological hotspot' areas of disturbance corresponding to the vulnerable areas, i.e. that subset of areas experiencing land use change (in the scenarios) which accounts for most of the hydrological changes.

Characterize the hydrological hotspot areas in terms of biodiversity and population; which also feeds into BNPP PB 4.

Note specific attention to flooding and drought risk in UNH activities described below (next page).

Specific Activity 1.A. tasks for IFPRI

Improved spatial characterization of the focus area at the pantropic scale.

This involves several sub-activities corresponding to the main themes of this project.

Activity I.A.ii. Integrate improved data on human population distribution. Integration of new spatial data sources on the location, size and population density of urban areas, as well as significantly revised estimates of rural population density (becoming available during 2002 from IFPRI funded studies).

Activity I.A.iii. Develop scenarios for areas of rapid change in land cover. Within the pantropic domain, forest areas at risk of disturbance will be identified, using newly available global evidence on fire locations and impacts, together with information on road infrastructure as well as forest/agriculture mosaic land cover types. This information, together with qualitative information on land use change processes, will be used to develop scenarios for the location and nature of land cover change.

Note: I.A.ii and iii also feed into BNPP PB #5.

Activity I.A.iv. Oversee and collaborate with UNH on the synoptic modeling of hydrological impacts of land use change. This subactivity will build on the land cover scenarios developed in Activity 1.A.iii and will be coordinated by IFPRI but implemented primarily by UNH. The model will apply a synoptic river basin analysis tool to quantify the hydrological impacts of pan-tropical land use change (including impacts of changes within the humid pantropics on other areas). The activity will compile or develop simple rules of thumb that relate hydrological functions (tentatively including total yield, dry season flow, flooding, and sediment generation) to land cover and climate. The rules will be refined based on the meso-model comparisons of Activity 2. The rules will be integrated with a 50 km resolution gridded pantropic synoptic model that represents water balance and transport and uses as input historic data on climatology. The synoptic model will be applied to two scenarios of land cover change to derive the spatial distribution of impacts for each of the functions, evaluated at different return periods.

<u>Specific tasks and responsibilities of UNH</u>

<u>Background</u>. The specific objective of the sub-contract with the University of New Hampshire will be to develop a provisional analysis and report on the use of state-of-the-art river analysis tools and data sets to quantify the condition, use, and/or vulnerabilty of tropical forest hydrosystems. The work will explore use of advanced river basin analysis tools to develop indicators of the contemporary state of key water-related vulnerability issues in tropical forest-dominated river systems. The lack of observational data sets for articulating the land surface hydrology over much of the pan-tropics means that the vulnerability and assessment communities are in great need of practical analysis tools. Through expertise developed at the University of New Hampshire's Water Systems Analysis Group and a suitable modification of its TYGRIS / Typology of Global River Systems codes, we will demonstrate the use emerging GIS, models, and "appropriately-scaled" biogeophysical data sets to develop a typology system for tropical river systems, permitting extrapolation from well-known to poorly-known drainage basins. This initial analysis emphasize the full pan-tropical domain but will also lay the groundwork for a multiple-scale study under future funding. The contract will include a technical report summarizing key findings and a proposal for future, more comprehensive research.

<u>UNH activities</u>: pan-Tropical Analysis of Climate Variability and Water Stress to be conducted as a contribution to Activity 1.A.iv, physical hydrology. A time series analysis spanning 1960 - 1995 (and thereafter if data available) will be performed exploring the use of monthly time scale forcings across the pan-Tropics to quantify river-basin response to climate anomalies including extreme drought and runoff. Persistence measures, exceedence probabilities, and other hydrological statistics will be presented. Data sets for human population, land cover, and topography will be united and analyzed in the framework to identify populations at risk from flooding and drought. Patterns of extremes will be correlated with areas of rapid land cover change. Anticipated gridded spatial resolution: 50 km x 50 km.

Specific UNH deliverables: technical report summarizing the major findings of the three sub-studies [need to clarify these; what about Central America] will be prepared. In addition to the biogeophysical analysis, the report will also consider the efficacy of the alternative grid resolutions and attempt to draw conclusions on the suitability of each for alternative applications.

3.5 Other published sources

UNH team website

BNPP PB #1. Bebunking myths about rainforests and watersheds.

Chomitz KM and Nelson A. The forest-hydrology-poverty nexus in Central America: an heuristic analysis. (under review)

4 **Template for third ASB BNPP Policybrief** ***(first rough draft, not for quotation)***

4.1 Working title: Deforestation and local hazards

4.2 Highlights

Among neighbours *(Picks up local effects where first BNPP policybrief left off)*

How trees matter

Forests or trees?

Stop evicting, start negotiating *(local politics / organizing for action / watershed networks)*

Sidebar ('strawman'): Much harm has been done in the cause of watershed management aimed at 'reforesestation'. Eviction of communities farming in upper catchments disrupts [hundreds of thousands of lives], often of relatively poorer, politically dis-enfranchized, ethnically marginalized groups. Efforts to reforest typically are neither effective nor necessary. Much more could be accomplished – without social dislocation – through negotiation with land users and through removing disincentives to land use and landscape management practices that serve community livelihood needs and meeting the hydrological needs of local people and downstream users too.

Lead: AGROFORESTRY SYSTEMS that are intermediate between natural forests and intensive foodcrop agriculture can maintain most if not all watershed functions attributed to tropical rainforests.

Page 1 image: Sumber Jaya, Lampung, Southern Sumatra landscape including: distant forest, coffee mixed erosion test plots, steep slopes, and rice paddies below, with annotations. Phote credit: M van Noordwijk

Other images or text boxes (assuming a 4-page format):

Table 2 from ASB Lecture Note 7: How 3 aspects of forests are affected by human disturbance and how this in turn modifies the water balance

Trees, forest soil, forest landscape X

Terms of water balance affected

Effects of disturbance

Recovery time

Figure 4.1 p. 17 from ASB Lecture Note 7: Schematic development of a landscape in a sub-watershed and its effects on storm flow (flooding), net sediment loss (erosion/sedimentation), and dry season base flow (dry season water supply).

Or Figure 4 p 11 of van Noordwijk, Ranieri, and Tomich. Schematic impact of land use on quantity and timing of water supply

Text box (probably on watershed networks and local politics in Thailand)

4.3 'For more information'

Activities/deliverables related to Null Hypothesis 3. Land cover change has no significant effect on people in small watersheds / sub catchments.

Note: This brief would be project deliverable 5(d) – see master contract.

Manuscript deliverable 4(b) corresponding to Activity 2–see master contract—on relationship among land use change, biodiversity, and hydrological functions in small and medium basins, with particular reference to MMSEA.

4.4 Other published sources

UofW team website

ASB policybrief on 'empowerment through measurement' (forthcoming)

ASB Voices #6 ,7, 8

BNPP PB #1. Bebunking myths about rainforests and watersheds.

BNPP PB #2. Deforestation and vulnerability in large river basins.

van Noordwijk M, Tomich TP, and Verbist B. Negotiation support models for integrated natural resource management in tropical forest margins. *Conservation Ecology* 5(2) (2001). URL: http://www.consecol.org/vol5/iss2/art21

van Noordwijk M, Ranieri S, and Tomich TP. (under review) Agroforestry, biodiversity and watershed functions of tropical land use mosaics" In G Schroth et al eds. *Agroforestry and Biological Conservation in Tropical Landscapes*

5 Template for fourth ASB BNPP Policybrief *(first rough draft, not for quotation)*

5.1 Working title: Biodiversity conservation through watershed management

or

Watershed values to finance biodiversity conservation

5.2 Highlights:

Functional clarity *(separating ecological and hydrological functions)*

Meeting in the middle *(landscape scale focus/scale of opportunities)*

Where on earth *(are the best opportunities for co-benefits)*

Its not going to happen *(in the Amazon and the Congo Basin)*

Sidebar ('strawman'): Biodiversity conservation and watershed management are intimately connected. In the humid tropics, the two sets of concerns overlap mainly at the landscape scale, where the pattern of trees and other vegetation can moderate flooding, sedimentation, and landslide risks while also serving as habitats for forest species and corridors linking conservation areas. [scale of landscape opportunities] However, there are few specific links between rainforest conservation and watershed management either at the plot level or at the national/global level.

Lead: NATURAL FORESTS are widely recognized both as sources of clean water and habitats rich in biodiversity, but functional links between the two have been exaggerated.

Page 1 image: tropical landscape mosaic

Other images or text boxes (possibly a 2 page format):

Map. Within the biome, overlay of the hydrological hotspot areas with areas of globally significant biodiversity. (See IFPRI Activity 1.a.iii. below.)

Figure 14 p. 24 from van Noordwijk, Ranieri, and Tomich: x axis: altitude; y axis 1: biodiversity values; y axis 2: watershed values; mismatch in the Philippines between protected areas/remaining natural habitat and bird species richness based on MacKinnon 2001

Table 6 from pp 22-23 of van Noordwijk, Ranieri, and Tomich: Biodiversity conservation and watershed functions at various scales:

Global/continental; National/river system; Landscape; Plot

5.3 'For more information'

Activities / deliverables related to Null Hypothesis 4. There is no significant spatial coincidence between globally significant habitats and key watershed management areas

Note: This brief is one of 3 fulfilling deliverable 5(c) – see master contract.

Manuscript deliverable 4(a) corresponding to Activity 1–see master contract—on delineation at the global scale areas and populations that are (or are not) at potential risk from the hydrological impacts of land use change in the study focus areas (the tropical rainforest biome); and the degree to which threat-posing land use change also impacts biodiversity. (on the former, see BNPP PB #2)

Manuscript deliverable 4(b) corresponding to Activity 2–see master contract—on relationship among land use change, biodiversity, and hydrological functions in small and medium basins, with particular reference to MMSEA.

<u>Activity 1.A.iii. (led by IFPRI):</u>

Characterize the hydrological hotspot areas in terms of biodiversity and population.

(also feeds into BNPP PB 2 and 5).

5.4 Other published sources

BNPP PB #1. Bebunking myths about rainforests and watersheds.

BNPP PB #2. Deforestation and vulnerability in large river basins.

van Noordwijk M, Ranieri S, and Tomich TP. (under review) Agroforestry, biodiversity and watershed functions of tropical land use mosaics" In G Schroth et al eds. *Agroforestry and Biological Conservation in Tropical Landscapes*

6 Template for fifth ASB BNPP Policybrief ***(first rough draft, not for quotation)***

6.1 Working title: Biological riches and human poverty

6.2 Highlights

Rich ecosystems *(where they are)*

Poor rural people *(where they are)*

Contrasting endowments *(of biodiversity and rural population densities)*

- Low density options (for Amazon, maybe Congo Basin)
- High density dilemmas

Sidebar ('strawman'): Conversion of these tropical forest ecosystems to other uses leads to the greatest species loss per unit area of any land cover change. But no more than ten percent of these forests will be within protected areas in the foreseeable future. The other 90% are home to [XXX] million rural people, most of whom depend on agriculture for their meager incomes.

Lead: IN A CLASS BY THEMSELVES as the richest terrestrial vegetation by far, tropical forest ecosystems also are home to hundreds of millions of extremely poor people.

Page 1 map(s): rural population densities and globally significant ecosystems

Question: should we use current population densities (say as in CIESEN)? Are any projections available, say for 2020 or 2050?

Other images or text boxes:

Map: soils as destiny (adapted from IFPRI Phase I work by Kate and Stan)

Tabulations:

How many WWF Global 200 'critical' ecosystems fall within the tropical rainforest biome?

Note: What else can we learn about these? Eg, anything regarding threatened species extinctions by ecosystem? What do the Global 200 tell us about biodiversity? These are extensions of IFPRI Phase I work.

For each ecosystem within the tropical forest biome,

total area 'protected'

total rural area outside protected areas

total rural area outside protected areas that is deforested (adapted from IFPRI Phase I work; also see PB #2)

total rural population

rural population density (relative to rural area outside protected areas)

6.3 'For more information':

Activities / deliverables related to Null Hypothesis 5. There is no significant spatial coincidence between globally significant habitats and rural populations in the tropics.

Note: This brief is one of 3 fulfilling deliverable 5(c) – see master contract.

<u>IFPRI Activities / deliverables</u>

<u>Activity 1.A. Improved spatial characterization of the focus area at the pantropic scale.</u>

This involves several sub-activities corresponding to the main themes of this project.

Activity 1.A.i. Assemble more detailed information on biodiversity-rich tropical habitats. Building on Phase I findings, the tropical rainforest biome of WWF (the 'Tropical and Subtropical Moist Broadleaf Forests" in the WWF nomenclature) will be adopted as the primary determinant of the focal area for study, instead of climatically-derived agroecological zones. Consultation will be undertaken with WWF on improving the spatial characterization of the Global 200 Ecoregions (nested within the tropical rainforest biome) and their associated species type and population databases. These amendments will be integrated within the analysis of the problem domain. Disaggregation of the pantropic analysis using the Global 200 Ecoregions will facilitate links with regional analyses.

Activity 1.A.ii Integrate improved data on human population distribution. Integration of new spatial data sources on the location, size and population density of urban areas, as well as significantly revised estimates of rural population density (becoming available during 2002 from IFPRI funded studies).

Activity 1.A.iii. Develop scenarios for areas of rapid change in land cover. Within the pantropic domain, forest areas at risk of disturbance will be identified, using newly available global evidence on fire locations and impacts, together with information on road infrastructure as well as forest/agriculture mosaic land cover types. This information, together with qualitative information on land use change processes, will be used to develop scenarios for the location

6.4 Other published sources

ASB Policybrief #5. Balancing Rainforest Conservation and Poverty Reduction (in press)

BNPP PB #2. Deforestation and vulnerability in large river basins.

BNPP PB #3. Deforestation and vulnerability in small watersheds.

BNPP PB #4. Biodiversity conservation as byproduct of watershed management

Cannon J and Surjadi P. Community livelihood and incentives for conservation in the Togean Islands, Indonesia. *Agriculture, Ecosystems and Environment* (forthcoming).

Chomitz KM and Nelson A. The forest-hydrology-poverty nexus in Central America: an heuristic analysis. (under review)

Nyhus P and Tilson R. Agroforestry, elephants, and tigers: balancing conservation theory and practice in human-dominated landscapes of Southeast Asia. *Agriculture, Ecosystems and Environment* (forthcoming).

van Noordwijk M, Ranieri S, and Tomich TP. (under review) Agroforestry, biodiversity and watershed functions of tropical land use mosaics" In G Schroth et al eds. *Agroforestry and Biological Conservation in Tropical Landscapes*