Developing a spatially-explicit, sustainable and risk-based insurance scheme to mitigate human–wildlife conflict

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Insurance may encourage coexistence between farmers and wildlife by reimbursing farmers’ losses. China introduced an insurance scheme to mitigate human–elephant conflict in Xishuangbanna Dai autonomous prefecture in Yunnan Province, where elephants cause damage to rubber plantations. However, recent experience has suggested that the present insurance system exhibits poor performance related to funding shortfalls, undervaluation of plantations and insufficient payouts, and by limiting community involvement. To address these shortcomings we conducted attitude surveys with farmers, and developed an actuarial (risk-based) insurance model for rubber loss that incorporated spatially-explicit risk of predation and net present value of rubber at damage, in order to calculate fair payouts at village and town levels for the year 2011. Farmers were largely dissatisfied with the current insurance system, and their level of satisfaction was associated with the compensation ratio (percentage of lost rubber reimbursed by insurance). The illustrative results based on 2011 rubber loss data revealed high variability in risk and therefore payouts (and further, premiums) and that fair insurance payouts would be approximately five times the current levels. To improve compensation and support long-term program sustainability, we considered an insurance cost-sharing mechanism that incorporated shared payments from government, rubber farmers, and Chinese tourists. We found that multiple stakeholders were willing to pay for elephant conservation, which could make significant contributions to insurance premiums over the long term. Importantly, this proposed insurance model could be broadly applicable to livestock and long-lived cash crop compensation systems.

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1. Introduction

Human–wildlife conflict (HWC) is an important driver of population declines of many threatened species (Banerjee et al., 2013; Woodroffe et al., 2005). In order to conserve species that generate conflict with people, there is a need to secure the rights and livelihoods of rural residents who face the conflicts, bear the cost imposed by wild animals, and may want the “pests” to be eradicated (Dickman, 2010). To reduce hostility of farmers towards wildlife, and the resulting retaliatory or pre-emptive killing, compensation schemes may be implemented, often in combination with other mitigation such as deterrents and barriers to prevent damage, and awareness campaigns to increase people’s tolerance to wildlife (Nelson et al., 2003; Woodroffe et al., 2005).

Compensation—the reimbursement to individuals or their families who have experienced wildlife damage to crops, livestock, or property, or who have been injured, killed, or physically threatened by wildlife (Nyhus et al., 2005)—can incentivize coexistence, especially when HWC is chronic and the economic impact of wildlife-attributed loss is substantial. While several successful compensation schemes have been reported across a range of human–wildlife settings (e.g. Maclean et al., 2009; Nyhus et al., 2005), some compensation programs have failed to encourage coexistence and sometimes even worsened HWC (e.g. Gussot et al., 2009; Mishra, 1997; Naughton-Treves et al., 2003; Ogra and Badola, 2008). Reasons for failure are various and include inadequate compensation, lack of sustainable funding and the creation of incentives detrimental for conservation—so-called ‘moral hazards’ that may include over-reporting of losses (Bulte and Rondeau, 2007, 2005; Dickman et al., 2011; Nyhus et al., 2005).
Insurance is a form of compensation that requires participants to pay a premium for their involvement (Dickman et al., 2011); this mechanism is gaining recognition as a potential improvement to traditional compensation, for several reasons. First, if based on actuarial (risk-based) analyses, insurance can promote fair payments by incorporating in the premium the spatially-explicit risk of HWC with the fair market value of the insured goods. For example, HWC incidents could potentially be linked to a predictable set of habitat features such as wild prey/food availability and live- stock/crop accessibility (Hill, 1997; Naughton-Treves, 1998; Redpath and Thirgood, 1999; Sitati et al., 2005, 2003; Stahl et al., 2002). Moreover, net present value (NPV) could be incorporated to estimate an actual/potential cost of losing an animal or long-lived cash crop (e.g. rubber, oil palm, coconut), including the expected future profitability (Yi et al., 2013), Considering risk heterogeneity and fair market value could lead to spatially variable, effective and equitable premium estimates and payouts. Third, an insurance-based compensation system could be sustainable if it were supported by multiple stakeholders, such as community funds and locally-generated wildlife revenues through, for example, ecotourism. Local generation of funds reduces dependence on external sources, allocates responsibilities for conflicts among stakeholders, and spreads risk among households when wildlife damage to individual farmers is highly stochastic and unpredict- able (Dickman et al., 2011; Madhusudan, 2003). For example, a cost-sharing mechanism has been used to mitigate human-snow leopard conflict in Pakistan and India (Hussain, 2000; Mishra et al., 2003). Finally, insurance may also prevent moral hazards by generating incentives for farmers to protect their assets and reduce false claims as premiums increase with risk, and because farmer's eligibility for insurance can be made conditional on their adoption of best practices for damage prevention (e.g. Woodroffe et al., 2005).

1.1. Human–elephant conflict in southern China

Driven by the transition to a market-driven economy since the 1950s, lowland forest conversion into rubber (Hevea brasiliensis) plantations has become the hallmark of tropical southern China, especially in Xishuangbanna Dai autonomous prefecture. Xishuangbanna is home to China’s remaining 190–236 wild Asian elephants Elephas maximus (Chen et al., 2012). The expansion of rubber has occurred at the expense of wildlife habitat and the simplification of local livelihoods (Fu et al., 2010; Li et al., 2009; Ziegler et al., 2009), and has led to an increase in human–elephant conflict (HEC) owing to frequent damage to rubber plantations. Elephant damage to rubber is characterized by the killing of seedlings and young saplings as elephants pass through the plantations to raid agricultural crops (rice, maize, banana). Feeding on rubber seedlings and saplings may also happen, as Malaysia reported rubber being raided by wild elephants to take in minerals deficient in their diets (Blair et al., 1979). Because of the high economic value of rubber, depredation by elephants inspires extreme local hostility (Chen, 2012). Farmers are least tolerant of damage to high-value cash crops (Messmer, 2000), so the increase in the market value of agricultural land further worsens the HEC found in China. From 1918 to 2005, 67 elephant deaths and 7 injuries were recorded as the result of retaliatory killing and poaching, and from 1991 to 2004, 21 human deaths and 91 injuries were attributed to elephants (Chen et al., 2012).

A host of technical measures to mitigate HEC have been implemented in China since the 1990s, including electric fences, trenches and walls (Chen et al., 2012). However, those attempts proved infeasible to use at a large scale in Xishuangbanna for various reasons. Building and maintaining trenches and walls incur high costs, may have short lifespans in the mountainous landscape, or may not allow for expansion of private agricultural land. Electric fences, while effective to mitigate HEC in many situations, have often been poorly designed and require maintenance, making them ineffective and/or costly. Moreover, fences erected around protected areas could disrupt elephant movements through critical conservation corridors in Xishuangbanna, which link Mengla and Shangyong protected areas; and Shangyong and Nam Ha (Lao PDR) nature re- serve (Xi, 2009).

In 2009 Chinese authorities in Xishuangbanna began incorporating insurance as a HEC mitigation tool, by replacing the traditional technical tactics with compensation to farmers for agricultural losses caused by elephants. Wildlife mitigation fund-
ing from the national government to Xishuangbanna prefecture is budgeted towards payments to a private insurance company. Once crop damage occurs and is reported, insurance agents are responsible for loss verification and compensation.

Although the existing insurance scheme has brought positive changes of local attitudes towards wild elephants (Chen, 2012; Chen et al., 2012), recent experience has suggested that centralized insurance exhibits poor performance by limiting community involvement, by not utilizing other conservation funds to support the payments, and by not considering the spatial heterogeneities of conflict intensity and market value of crops (e.g., compensation for each lost rubber tree is US$ 2/tree regardless of age or productivity; Chen, 2012). Furthermore, funding shortfalls for the HEC insurance scheme threatens its long-term sustainability. For example, in 2010 there was a budget of US$ 450,000 for the HEC insur-
ance scheme; and in 2011 there was a budget of US$ 1 million for all HWC insurance (although the amount allocated to HEC was not specified in the governmental budget, HEC compensation accounted for 87% of the actual cost of the HWC insurance in this year; Chen et al., 2012). The allocated budget, in any case, was insufficient to cover HEC-compensation, which was as much as US$ 693,000 in 2010 and US$ 1,371,000 in 2011 (Chen et al., 2012). The insurance company, thus, lost money in both years and therefore an improved system to fund this insurance scheme is needed to help mitigate HEC in China.

The costs of rural residents living alongside threatening wildlife may be shared by the wider beneficiaries, such as tourists (Dickman et al., 2011). Tourism, as one of the “non-consumptive but sustainable” uses of wildlife, can help to achieve conservation goals by offsetting local costs of coexistence and enhancing supportive conservation attitudes. As a charismatic flagship species, elephants attract tourists and may support a successful and sus- tainable ecotourism project (Kruger, 2005). In Xishuangbanna, tourist visits to Elephant Valley, a famous elephant-oriented attraction, nearly doubled from 2007 to 2012 (0.68 million in 2007, 0.83 million in 2008, 1.04 million in 2009 and 1.21 million in 2011; Xishuangbanna Nature Reserve Bureau, unpublished data). At present, tourism revenues are not allocated to HEC, nor has there been assessment of tourists’ willingness to pay for wild elephant conservation. Tourism revenues may repre-
sent a significant opportunity to relieve the financial deficiency of the current insurance scheme in Xishuangbanna.

In this paper, we propose an actuarial insurance system to help mitigate the conflict between farmers and wild Asian elephants in Xishuangbanna. Our objective in this study was to develop an improved insurance-based compensation system by taking into account the spatial heterogeneity of conflict intensity and market value of rubber trees, and by distributing the costs of HEC mitigation across multiple stakeholders who have a vested interest in the program’s success. We calculated the full-indemnity insurance payouts at both the village and town level based on spatially-explicit HEC risk and rubber NPV at damage, estimated insurance pay-
outs for HEC in the area, and used the results along with willingness-to-pay data to recommend a sustainable cost-sharing
insurance scheme jointly paid by the government, rubber farmers, and tourists.

2. Methods

2.1. Study area

This study was conducted in Xishuangbanna (19,700 km², 21°09′–22°33′N, 99°58′–101°50′E) on the southernmost margin of Yunnan province, bordering Laos and Myanmar (Fig. 1). Xishuangbanna has very high biodiversity—it is included as part of the Indo-Burma biodiversity hotspot (Myers et al., 2000) and is defined as one of the key Biodiversity Conservation Corridor Initiative focal areas in Greater Mekong Subregion (Xi, 2009). Due to agricultural (mainly rubber) expansion, most of the remaining forest is located within the boundaries of the Xishuangbanna Biosphere Reserve, which consists of five discontinuous nature reserves in a matrix of different land-use practices (Li et al., 2007)(Fig. A.1). Our study was carried out in Shangyong Nature Reserve (NR), which borders Lao PDR, harbors 60–80 wild Asian elephants (up to 30% of all remaining elephants in China, Chen et al., 2012), yet which faces intense HEC (Chen, 2012) and involves complex trans-border coordination. This study focused on 26 villages of three townships around Shangyong NR that reported recent cases of HEC (Fig. 1).

2.2. Development of a spatially-explicit HEC risk map

We interviewed key informants from Xishuangbanna Wildlife Department to obtain information on villages next to Shangyong NR that had experienced HEC between 1991 and 2012. From those interviews, 26 villages were identified, and subsequent interviews were conducted with village heads and patrolmen regarding whether the village experienced HEC in the previous two years. Among the 26 villages, 12 reported elephant crop raiding occurring between January 2010 and January 2012.

In the 12 study villages, we randomly selected a minimum of 20% of households in each village (n = 208). From January to March 2012, semi-structured interviews were conducted in the local language, with male or female household heads who worked on the farms on a daily basis. Surveys captured information on household socio-demographic characteristics; rubber mortality by elephants during the year 2011; perceptions towards the current insurance scheme; and willingness to pay (WTP) for rubber insurance premium (in CNY/mu, later converted into US$/ha) and to share the costs with government if full indemnity were guaranteed. For WTP, each respondent was asked to vote “yes” or “no” for an ascending sequence of bids in the form of a double-bounded dichotomous choice question. If the respondent voted “yes” for a bid, the next bid was raised, and this process continued until the respondent voted “no” or the highest bid value in the bid list (CNY 60/mu or about US$ 134/ha) was reached. When the respondent voted “no” the willingness of the respondent to pay the previous bid was re-confirmed. In addition to WTP, farmers provided information on the age, total number of rubber trees, and the number of trees killed by elephants in each plantation for the year prior (2011). Mortality reporting was limited to only the year prior to reduce recall bias. Subsequently, with the help of experienced farmers and forest patrolmen in each village, GPS points were collected at the locations of the most rubber mortality reported in 2011 (n = 7–51 per village).
For each study village, the percent rubber loss of all interviewed households for 2011 was used to represent that village's risk to elephant depredation. Depredation risk (i.e., conflict risk) was then mapped and simulated with spatial kriging interpolation in ArcGIS 10.1 (ESRI, Redlands, CA, USA).

2.3. Modeling annual payouts for elephant attacks

In a previous study, Guo et al. (2006) used NPV to evaluate the market value of rubber in Hainan Province, China, applying the following equation:

\[
NPV_{\text{rubber}} = \frac{\sum_{t=0}^{T} R_{\text{latex}t} \cdot (1 + r)^{-t} + R_{\text{timber}t} - \sum_{t=0}^{T} C_t \cdot (1 + r)^{-t}}{[(1 + r)^T - 1]}
\]

(1)

where \(R_{\text{latex}t}\) is the revenue from latex tapping in the year \(t\) which is determined by latex production that is age-correlated and influenced by management regime and environmental factors; \(T\) is the rotation age of rubber; \(R_{\text{timber}t}\) is the final harvest income from timber; \(C_t\) is the annual cost; and \(r\) is the social discount rate, which is a measurement used to guide the resource and public investment allocations, reflecting relative valuation between today's well-being and the one in the future (Zhuang et al., 2007). We selected a social discount rate of 8%, as suggested by the Asian Development Bank (Zhuang et al., 2007).

For this study, the cost of rubber damage \(C_{\text{damage}}\) pertained to (1) the cost of replanting rubber seedlings killed by elephants, and (2) the loss of NPV over final years due to delay of latex harvest because all trees—including those replanted after loss—are harvested at the same time (Fig. A.2). We assumed no loss of timber revenue at harvest. The equation took the form:

\[
C_{\text{damage}} = \sum_{t=0}^{t'} C_t \cdot (1 + r)^{-t} / [(1 + r)^T - 1] + NPV_{T - t'}
\]

(2)

where \(t'\) is the age of rubber attacked and \(NPV_{T - t'}\) is the loss of NPV when the plantation is harvested prior to the end of the tree's lifespan. However NPV is also affected by elevation (Yi et al., 2013), according to age at damage (1–4 years) and the previously calculated NPV (Table A.1). A linear regression was then produced, with plantation elevation and age at damage as predictors, and \(C_{\text{damage}}\) as the dependent variable. The final regression took the form:

\[
C_{\text{damage}} (\text{US$/ha}) = 2607.351 + 1810.583 \text{ age} - 3.638 \text{ elevation}
\]

(3)

Data from the field surveys were entered into this regression to estimate the village-specific \(C_{\text{damage}}\). Where age was the weighted average age at damage across all respondent households in the village, and elevation was the average elevation of all GPS points taken at damage sites in the village. \(C_{\text{damage}}\) (US$/ha) was also converted to a \(C_{\text{damage}}\) value per tree, based on a typical rubber planting density of 495 trees/ha (Yi et al., 2013).

The annual (year 2011) payout was calculated as \(C_{\text{damage}}\) multiplied by the percent rubber loss of 2011. This was converted to a village-level payout by multiplying the per-ha annual payout by the projected total area of rubber plantations in the village (the mean area for sampled households multiplied by the total number of households in the village). Town-level payout was also calculated by summing up the gross payouts of villages from the same town.

2.4. Attitudinal analysis of farmer's perception towards current insurance scheme

Responses from the questions on attitudes towards the compensation scheme (see Section 2.2) were ordinal, from the most negative (1: Current insurance is worse than the previous HEC mitigation measures) to the most positive (4: I am fully satisfied with the current insurance scheme and it should be applied widely). We applied classification inference trees (CIT) to the data to identify variables shaping farmer perception towards the current insurance scheme. CIT is a nonparametric technique that employs a statistical stopping criterion to split the data set into binary groups repeatedly based on the association between covariates and response, until the recursion needs to stop and generate an optimal decision tree (Giam et al., 2011; Hothorn et al., 2006, 2011). The CIT was constructed in R using the package “party” (Hothorn et al., 2011) and we set Monte Carlo \(P < 0.10\).

2.5. Tourist surveys

In March 2012, a tourist survey was conducted at the Elephant Valley, a popular tourist attraction in Xiushangbanna, to examine tourists’ willingness-to-pay for HEC mitigation. A total of 210 independently sampled tourists (123 male, 87 female) were surveyed by semi-structured questionnaires to capture information on their socio-demographic characteristics, level of knowledge about of HEC, and their WTP for HEC mitigation to conserve wild elephants in China. Most respondents were Chinese tourists from provinces outside Yunnan (\(n = 160, 76.2\%\)), and a small proportion of tourists were from overseas (\(n = 5, 2.4\%\)). The remainder of tourists was from Yunnan province.

3. Results

3.1. Farmer perception towards the current insurance scheme

Overall, only 3.8% (\(n = 8\)) of the 208 interviewed farmers were fully satisfied with the current insurance scheme. Most complaints about shortcomings were due to “unreasonable” compensation such as reimbursement of a fraction value of the market price, inefficiency of damage verification, non-timely payment, and low compensation ratio (percentage of lost rubber claimed by respondents that was reimbursed by the insurance company), followed by rude service and perceived unfairness.

In general, the village of residence and compensation ratio determined farmer satisfaction towards the current insurance scheme (Fig. 2). About 85% of the farmers in Villages 1 (Shangzhongliang), 2 (Manfen Shang), 7 (Xiazhaoxiangliang), 11 (Dashujiao) and 12 (Zhongnanxi) perceived the current insurance as worse than the previous HEC mitigation measures, or that insurance did not bring any improvement. Villages 7, 11 and 12 received no compensation in 2011. In the other study villages, 80% of rubber holders who had received more than 22% compensation (i.e. a compensation ratio >22%) perceived insurance more positively, e.g. that insurance helped to reduce loss effectively, albeit with some shortcomings. In contrast, attitudes among those who received ≤22% compensation were equally positive and negative.

3.2. Rubber loss dynamics and expected payouts

In 2011, elephants reportedly killed a total of 13,071 rubber trees across the 208 respondent households. Approximately 92% were less than 5 years old and <1% were older than 8 years. The overall weighted average age at damage was 2.9 years (Table 1).
Conflicts were unevenly distributed among study villages, and the risk of loss ranged from 0.0% to 7.0% of the village's rubber trees (Table 1, Fig. 3). Villages in the west suffered considerably higher losses than in the east; risk was also associated with proximity to the reserve border. The greatest rubber mortality from wild elephants occurred at 600–950 m elevation.

Based on the elevation, NPV and age-corrected linear regressions, the mean cost of elephant-related rubber damage was US$ 9.9/tree (US$ 126.2/ha, Table 1), i.e. about five times higher than the current insurance payment of US$ 2/tree provided to farmers (Chen, 2012).

Commensurate with risk, higher expected rubber payouts were found at villages to the west of Shangyong NR than to the east (Table 2, Fig. 3). For the year 2011, the annual expected payout of villages ranged from US$ 0.3/ha to US$ 340/ha, corresponding to total village payouts of US$ 65 to US$ 245,000 (Table 2). At the town level, the estimated gross payouts were US$ 9628 (Mengpeng), US$ 17,004 (Shangyong) and US$ 471,612 (Mengman) (Table 2, Fig. 3).

### 3.3. Willingness to pay for insurance

A large proportion of rubber farmers (n = 126, 61%) believed a reasonable market-based compensation could mitigate their antipathy towards elephants and increase their tolerance of coexistence. Under the assumption of future full loss indemnity if insurance premiums were shared between the government and community, 61% of respondents were willing to pay for insurance, with a mean WTP of US$ 36.2 ± 42.2/ha. There was high variation in willingness: out of the 208 respondents, 39% expressed an unwillingness to pay for insurance; 10% were willing to pay 50–100% of the expected rubber payout; and 20% were willing to pay more than the full expected rubber payout (Fig. 4). A household’s willingness to contribute any amount to insurance was positively associated with the amount of rubber lost to elephants in 2011 (Table A.2).

The mean village WTP ranged from US$ 2–60/ha, contributing from 1.9% to more than 100% of gross village payouts, assuming all households would pay the mean WTP value for their village. The mean town-level WTPs were US$ 27.3–29.8/ha, contributing 14.4–100% of the expected gross rubber payout at the town level (Table 2).

In general, Chinese tourists were familiar with, and willing to contribute to, elephant conservation through financial support of insurance. A total of 68% of the 210 interviewed tourists knew about HEC, while 32% expressed unfamiliarity with the issue. Tourists generally supported wild elephant conservation and 90.5% were willing to help the mitigation of HEC in Xishuangbanna by contributing a donation of income to elephant funds (Fig. 5). The mean WTP per respondent was US$ 12.5 ± 13.2, which represents...
0.23% of the 2011 per-capita GDP for China of US$ 5447 (The World Bank n.d.).

4. Discussion

Fair compensation is important to make HWC insurance schemes successful (Nyhus et al., 2003), yet our results clearly show that in Xishuangbanna the present payout system of US$ 2 per depredated rubber tree is severely inadequate. According to our model, the average payout should be about five times higher and vary according to age at death and site-specific NPV. In a survey of Xishuangbanna farmers, 65% of them prioritized compensation as a future HEC mitigation measure (Chen, 2012), and 61% of rubber farmers in this study stated that they would have more

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Table 2

Gross rubber payouts of villages and towns.

<table>
<thead>
<tr>
<th>Villages</th>
<th>Households</th>
<th>Land area (ha)</th>
<th>Unit payout (US$/ha)</th>
<th>Gross payout (US$)</th>
<th>Mean WTP of farmers (US$/ha)</th>
<th>Gross WTP of villages (US$)</th>
<th>Contribution of WTP to gross payout (%)</th>
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</thead>
<tbody>
<tr>
<td>Mengman Town</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Shangzhongliang</td>
<td>136</td>
<td>721</td>
<td>339.71</td>
<td>244,931</td>
<td>14</td>
<td>10,094</td>
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<td>127</td>
<td>430</td>
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<td>89,251</td>
<td>29</td>
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<td>136.23</td>
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<td>5536</td>
<td>14</td>
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<td>–</td>
<td>471,612</td>
<td>–</td>
<td>67,691</td>
<td>14.4</td>
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<tr>
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<td>9171</td>
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<tr>
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<td>17,004</td>
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</table>
positive attitudes towards wild elephants if fair-market compensation were provided, thus supporting economic compensation as a potential HEC mitigation strategy. Moreover, we found substantial local and regional willingness to pay for elephant conservation via insurance, provided that full compensation would be assured. We therefore conclude that the current compensation scheme utilizing flat premiums and payouts could be transformed into a more equitable and economically sustainable actuarial insurance scheme by (1) incorporating spatial heterogeneity of HEC risk and rubber crop NPV in the calculation of both premiums and payouts, (2) creating a system to share the cost of premiums among different stakeholders (government, farmers, and tourists), and (3) achieving long-term buy-in of all stakeholders.

We found that rubber depredation by elephants around Shangyong NR was an idiosyncratic event, as it is elsewhere (Campos-Arceiz et al., 2009; Hoare, 1999; Sitati et al., 2003), and hence economic losses varied greatly across space. Consequently, the need for spatially variable payouts (and likewise premiums) is evident. However, the spatial dynamics of elephant conflict likely vary temporally as well (Campos-Arceiz et al., 2009; Chiyó et al., 2005), and so must be incorporated into a multi-year spatiotemporal risk model. The case study utilized here was generated on one year of rubber loss data based on recall of farmers, and is therefore only illustrative and not predictive. Nevertheless it demonstrates the inadequacy of a flat premium and payout system, and lays a solid foundation for implementation and improvement going forward, as more depredation events are recorded in spatiotemporal databases. It will be crucial in the case of Shangyong NR, as with any system utilizing a spatiotemporal risk-based insurance scheme, to determine whether rubber losses are spatially predictable across years so that premiums could fairly reflect HEC risk. Fluctuation of rubber price could also affect the estimates of NPV and insurance payoffs. A fair system will require significant investment by the government to introduce a continuous, systematized HEC monitoring, reporting, and economic analysis system, and by insurance providers to incorporate those data into dynamic and transparent calculations of risk-based premiums.

Long-term economic sustainability is a major concern when establishing a HWC mitigation insurance scheme (Dickman et al., 2011; Nyhus et al., 2005). In this study we calculated the gross payout, which when adjusted for risk should correlate with premiums paid by villages. However, premiums will also include insurance administration costs, profit margins and underwriting charges, as well as the dynamic effects of timing of cash flows, risk of inflation, and uncertainty of basic economic state variables (Kraus and Ross, 1982). Despite our inability to calculate what premiums might be for the villages, the premium associated with an annual gross payout of approximately US$ 500,000 for these three townships (Table 2) would exceed the entire 2010 insurance budget for HEC in Xishuangbanna prefecture of US$ 450,000 (Xishuangbanna Nature Reserve Bureau, unpublished data). The 2011 governmental budget for all wildlife damage was US$ 1 million, highlighting serious concern for the economic sustainability and social equitability of the program under current conditions.

Thus, our model proposing a partnership between government, local inhabitants and tourists in the formulation of a premium cost-sharing insurance mechanism could make a significant contribution towards fair-market payouts in Xishuangbanna. The data indicate a large and heretofore untapped source of funding from both internal and external stakeholders, which could offer a significant level of support to the program. From our illustrative case study, WTP interviews indicated that approximately 18.5% of the entire 2012 insurance premium of Shangyong NR could be contributed by farmer groups, and in low-risk areas of Mengpeng and Shangyong, rubber farmers could sustain their own insurance scheme (assuming continuance of risk levels).

In addition, the number of visitors to Elephant Valley has nearly doubled from 2007 to 2012 (0.68 million in 2007, 0.83 million in 2008, 1.04 million in 2009 and 2010 and 1.21 million in 2011; Xishuangbanna Nature Reserve Bureau, unpublished data), indicating substantial potential for tourist-based funding for the mechanism. Based on an average of 1 M visitors, the WTP of US$ 12.5/person could raise nearly US$ 12.5 million per year through the extraction of a percentage of entrance ticket fees; although implementation of this strategy must make more conservative projections of expected revenue as the WTP is unlikely to correspond to actual payments. This locally-generated tourist fund could address the current financial deficiency and support the overall insurance sustainability, and this form of conservation payment (Dickman et al., 2011) would successfully spread the costs of living alongside wild elephants to the wider beneficiaries of conservation. One obvious caveat that could limit the direct implementation of this model elsewhere, is that a significant source of revenue through tourism in Xishuangbanna lies within the same region as the HEC. Other HWC areas with low potential for ecotourism may not have this potential source for insurance payments, and thus a larger portion of total premium payments would fall on local people and the local government, or require novel mechanisms to attract funding. One such novel mechanism could be engaging large plantation companies (e.g. oil palm companies in...
Malaysia and Indonesia, pineapple companies in Thailand, tea and coconut companies in India and Sri Lanka) to create funds to subsidize HWC premiums for smallholders as part of the companies’ corporate social responsibility (CSR) programs.

Distributing insurance payments across numerous stakeholders could—if managed properly—create incentives to promote long-term sustainability of the scheme. For example, farmers have a major stake in securing their crops and thus demonstrated a willingness to undertake some responsibilities to protect their own assets and contribute to insurance premiums. Moreover, because premiums could be tied to risk, farmers might not have an incentive to over-report damage as (a) such behavior could lead to higher premiums in future years, and (b) premiums would be village-based and therefore over-reporting could be discouraged through village enforcement and social norms.

Importantly, sustainable development of any shared-cost insurance system requires buy-in from all participants (Treves et al., 2009). In Xishuangbanna, 39% of farmers indicated an unwillingness to pay into the system, largely because of mistrust towards the insurance firm and low probability of their rubber plantations being damaged by elephants; and 39% of farmers indicated that their antipathy towards elephants was unlikely to improve even with fair compensation, mainly due to fear, trauma and other imposed intangible costs. This echoes experiences in several African countries, where compensation programmes for elephant damage suffered from several deficiencies (African Elephant Specialist Group, 2002). An important first step to developing long-term buy-in by local participants is assurance of equitable and timely payouts. Our results showed that the major dissatisfaction of farmers to the present insurance scheme was the underperformance of the insurance firm, characterized by a low compensation ratio (<22%) associated with payment insufficiency and inefficiency. Improved transparency on the part of the insurance companies would be required in order to increase confidence of local farmers. In addition, improved accountability overall, through the development of transparent and responsive oversight mechanisms, government agencies could enforce regulations applied to insurance companies, to conduct on-the-ground monitoring so as to avoid moral hazards associated with faulty claims, and to offer transparency in allocating tourism-based revenues for elephant conservation (Nyhus et al., 2005).

In order to increase local buy-in, decreasing damage is a prerequisite for its success in the long run (Swenson and Andrén, 2005), and economic compensation alone is not necessarily enough to change people’s perceptions and tolerance towards wildlife (Naughton-Treves et al., 2003). This would require ancillary investment from local villages and the government, to reduce direct human–elephant encounters, such as the use and proper maintenance of small-scale barriers around crops, construction of biological corridors to link isolated reserves, or reforesting low-profitability rubber plantations in high conflict areas to create natural forest buffer zones, such as the marginally profitable rubber farms in Nanping Village that are exposed to the highest risk and required >US$ 300/ha annual payout. The eligibility for insurance should depend on farmers’ commitment to adopt a set of ‘best practices’ for damage prevention. For example, the human-wolf conflict mitigation programme is much more effective in Sweden where farmers are required to comply with good herding practices in order to be eligible for compensation, than in Norway where there is no such requirement (Swenson and Andrén, 2005). Socio-economic analyses can be included to help understand the reasons for low tolerance to wildlife among a part of the population and to design actions to increase it when appropriate (Banerjee et al., 2013). Buy-in on the part of insurance companies would include clear commitment to ensure fair, rapid and transparent claims response and payouts.

Finally, to operate this cost-sharing insurance scheme effectively, greater clarity is needed, and agreement reached, on the role each stakeholder will play. For example, the local government may take on the responsibility of raising funds from the national government and tourists, and to ensure that the funding is appropriately disbursed to not only insurance subsidies, but also to support education, outreach, and other mitigation activities (e.g. elephant trenches, walls or electric fences where appropriate and effective). Insurance firms may be obliged to provide services such as evaluating annual risk and cost, calculating actuarial premiums, providing compensation standards and allocating central funds to villages, all with improved accountability through third-party auditing. Finally, responsibility for raising community funds, administration of central funds and timely damage investigation for reporting to claims investigators could be decentralized and managed by communities through ‘village insurance committees’, which would be trained by, and work in collaboration with, the insurance firm. These mechanisms could enhance the efficiency of the insurance programme through the low-cost adjudication, reduce the administration cost of the insurer and incentivize villagers. Similar community-based insurance mechanisms have contributed to successful human-snow leopard conflict mitigation in Baltistan (Pakistan) (Hussain, 2000) and India (Mishra et al., 2003).

While insurance is not the panacea to resolve HWC (Bulte and Rondeau, 2005; Nyhus et al., 2005; Wagner et al., 1997), developing a multi-stakeholder insurance compensation system based on quantitative analysis of both risk and economic valuation of property loss, would make a significant contribution to enhancing coexistence of wildlife with rural communities. Such a model could be exported to other systems where elephants or other large herbivores produce damage on long-lived, high-value cash crops such as rubber and oil palm plantations throughout Southeast Asia and coconut plantations in India and Sri Lanka.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2013.09.017.

References


