Estimating the extent of illegal traditional Chinese medicine trade in Guangzhou, China using occupancy modelling

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DECLARATION OF OWN WORK

I declare that this thesis (Estimating the extent of illegal traditional Chinese medicine trade in Guangzhou, China using occupancy modelling)

is entirely my own work and that where material could be construed as the work of others, it is fully cited and referenced, and/or with appropriate acknowledgement given.

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List of Acronyms:

- QPD – Qing Ping Dong (Market)
- QPYYZX – Qing Ping Yi Yao Zhong Xin (Market: Qing Ping Medicine Centre)
- QPYC – Qing Ping Yao Cai (Market)
- QP – Qing Ping (Study area)
- QPL – Qing Ping Lu (Market)
- TCM – Traditional Chinese medicine
- WCS – Wildlife Conservation Society

Abstract:
Inspired by Barber-Meyer (2010), an occupancy survey was designed to pilot the use of occupancy modelling in traditional Chinese medicine markets. Careful considerations were given to the design with particular paid to fit the unique environment the traditional Chinese medicine market, and fulfil the assumptions of occupancy modelling. Survey commenced in May, 2012, and ended in July, 2012. Data collected was analysed under the null model to investigate the effect of randomised spatial clustering. Suggestions were made based on results and survey findings.

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1. Introduction:

The illegal trading of wildlife has long been an obstacle to species conservation. Of this, the trade in animal parts for traditional Chinese medicine is a major component (Zhang et al, 2008; Gong et al, 2009). Recent crisis in rhino poaching due to the demand for rhino horns in Asia has led to the extinction of the West African rhino and put years of rhino conservation effort into near obsolescence (TRAFFIC a., 2011). The confiscation of 33 rhino horns and ivory being smuggled through Hong Kong to China in November, 2011, has validated the long suspicion that China is one of the major consumers of illegal wildlife products (TRAFFIC b. 2011); its increasing economic power sustaining the activities of poachers. Yet it is with the demise of one of conservation’s most charismatic flagship species that international concern about the use of illegal wildlife products for traditional Chinese medicine is re-ignited. The extent of the trade within China however remains unconfirmed.

Rhinos are not the only victims of traditional Chinese medicine; many more other species are also used as traditional Chinese medicine ingredients. While understanding poaching can help to protect species in their habitats, the root of the problem lies in the demand side of the commodity chain; poaching will fail to cease unless consumption is curbed. In other words, to tackle any issue of illegal wildlife trade, the drivers for demand must be understood and the extent of the trade has to be addressed. Knowing the scope of illegal wildlife trade can instruct international conservation bodies and local governments how and where to allocate legal enforcement and awareness-raising efforts, and provide the most effective conservation actions for threatened species. Understanding spatial and temporal patterns in market dynamics can help identifying the efficacy of implemented laws and actions, market trends, and drivers for demand.

Location of study:

Guangzhou is the capital city of Guangdong Province, China. Being one of China’s largest and most populated cities (National Bureau of Statistics of China, 2012) near Southeast Asia’s notorious hotspot for cross-border trafficking, the Golden Triangle, it is no surprise that Guangzhou has become one of the centres of wildlife crime within China.

Qing Ping is an area situated in the centre of Liwan District, covering three building blocks. It is known locally as the traditional Chinese medicine hub, and is one of the major traditional Chinese medicine wholesale markets in China. It is also known for the availability and competitive prices of illegal wildlife products (WCS China, 2011; Trader A, 2011), which has made it the subject of study and monitoring for Wildlife Conservation Society (WCS) South China Project.
Wildlife Conservation Society – South China Project:

Wildlife Conservation Society (WCS) South China Project is a branch of WCS China Program, and has focused on tackling the illegal wildlife trade in TCM trade since 1997 (WCS China, 2011); representing one of the first international NGOs to focus on conservation issues surrounding illegal wildlife trade in South China, including bushmeat (particularly of testudines), pet, and traditional Chinese medicine (from here on TCM). WCS South China Project has established a base in Guangzhou in 2008, and it remains one of their focal areas. The project has three main goals; to educate the public and raise local conservation awareness, to facilitate the capacity building of local law enforcement in tackling wildlife crime, and to act as an independent body to monitor and tackle wildlife crimes. It is the last of the listed goals that motivated this study.

The challenge in monitoring illegal wildlife trade and studying its market dynamics lie in its secretive nature due to international and local pressure. The illegal selling of CITES-listed or nationally protected species and its products often entails insider-knowledge of the location and identity of sellers, and even personal relations. Sellers would often deny possession of these products unless they trust the potential buyers; some are reluctant to show the products unless money has changed hands; others will only obtain products to order. To make studying more difficult, sellers tend to evade specific questions on the specimens, such as stock quantity, and origin (wild or farmed, where cultural beliefs in medicinal power also plays a part).
Currently WCS-China conducts TCM market surveys in the area of Qing Ping to keep track of the presences, species, and types of illegal wildlife products available in each shop and market. The result is then followed up with law enforcements by local officials to eliminate the trade of illegal wildlife TCM products. However with high profitability and persistent demand, traders do not simply stop at the protection status of wildlife, instead the illegal status of wildlife products means transactions have become more secretive, and traders are more selective of their customers in fear of being apprehended. Even though the trade is known to be ongoing, WCS researchers are finding it increasingly difficult to monitor. Traders’ tendency to hide their illegal products implies a very variable (and potentially very low) detectability of illegal TCM products; simple presence-absence surveys used in the past no longer suffices in identifying the trade’s true extent and its temporal trends.

A lack of direct observations of illegal wildlife products in markets does not necessarily imply true absences, and to assume a lack of observation equals to a lack of illegal wildlife product is to introduce a negative bias into survey data. This difficulty in monitoring illegal wildlife trade parallels a different but not dissimilar problem in wildlife studies; animals with a low detectability. In response to the flaws of simple presence/absence modelling, occupancy models are developed by Mackenzie et al (2002), and MacKenzie et al (2003) to estimate more accurately the parameters that are used as surrogates for population abundance, occupancy probability. Seeing the similarities Barber-Meyer (2010) speculates that the method used for studying wildlife populations is transferrable to the monitoring of illegal wildlife trade in the market.

**Dealing with the Clandestine Nature of Wildlife-Trade Market Surveys:**

In a study published in 2010, Barber-Meyer discussed the potential use of occupancy models in the monitoring of wildlife trades. In this paper Barber-Meyer also analyses market data on tiger parts from Sumatra using a range of temporal and spatial scales. The inadequacy of presence-absence surveys to detect hidden trades is overcome using a field survey technique. The inclusion of what would otherwise be considered absent greatly improves the robustness of data. Its potential in exposing the full extent of illegal TCM wildlife trade and to increase statistical power of market survey results has substantial implications to conservation. If occupancy surveys can be applied to the TCM market, then we will have a standardised, accessible, and reliable method to monitor hidden wildlife crimes, and better evaluate and allocate our efforts and funding.

**Aim and objectives:**

Although Barber-Meyer (2010) has demonstrated that the application of occupancy modelling in markets is theoretically feasible, it has yet to be trialled in an actual market. Inspired by Barber-Meyer’s paper, this study is conducted to pilot the use of occupancy
surveys as a method to study and monitor illegal wildlife trade in a market for the first time, using the Qing Ping TCM markets to assess its applicability, to test its limitations, and to produce a standardised protocol for fellow conservationists to conduct market research.

More specifically this study aims to address the following questions:

- *In terms of occupancy modelling, how do markets differ from a wildlife habitat?*

- *Can the assumptions of occupancy survey be fulfilled in TCM markets?*

- *If not, can the survey design be adjusted to ensure statistical robustness and justify the application of occupancy modelling in the TCM market?*

- *How does survey design differ in the occupancy surveys of markets? And how will the element of human interaction affect the method?*

- *What are the limitations of conducting occupancy surveys in the TCM market?*

- *Can we standardise survey effort and produce protocols that enables long-term studies?*

- *Finally, is occupancy modeling the way forward for illegal wildlife trade monitoring?*

2. Background:

**Traditional Chinese Medicine and global conservation:**

The TCM trade has existed for more than 5000 years (Mainka and Mills, 1995), and has been a chronic conservation concern, but in recent years the pace and scale of exploitations appear to have increased at an unprecedented scale. How this sudden increase came about has not been addressed in scientific literatures, but the increasing economic powers of Asian countries are likely to be partly responsible. The increasing connections between Asia and Africa may also have a role in the expansion of wildlife crime.

In any case market surveys and quantification of illegal wildlife trade are vital to the deepening of our understanding of the extent of wildlife crimes. Conservationists need to be informed on what species are involved, how high the demand is, and where products are coming from. Although there is no lack of TCM-related conservation studies, TCM-related quantitative studies are scarce. The blatant lack of studies is the reason why we need to pilot a method to quantify this cryptic trade.
Conservation literatures that focus on the demand side of the wildlife trade commodity chain are seldom quantitative. Instead many of these are based on attitude surveys and molecular studies (e.g. Gratwicke et al, 2008). While both areas are indispensable to our understanding to the TCM trade, the importance of quantitative studies should not be undervalued, and nor should it be neglected simply due to inaccessibility.

Of the handful of studies based on the quantification or statistical modelling of wildlife trades, most are based on systems where detections are (or at least assumed to be) binary, i.e. detection results only in presence or absence, with no detection errors assumed (Vincent, 1997; Cheung and Dudgeon, 2006; Shepherd and Nijman, 2008; Gong et al, 2009; Silva Regueira and Bernard, 2012). These studies are usually set in bushmeat and pet markets because in both markets goods are perishable; the longer a trader hold on to their stock, the more likely it will go to waste, and trader will suffer a loss. In pet markets this effect is further amplified by the cost of keeping specimens alive. This incentivises traders to sell illegal wildlife products openly. However this is not true for TCM. TCM goods are much more durable in comparison to meat and live animals, and the keeping of products incurs no cost on the trader. In this case the benefit of holding on to their products and selling it at a safer time far exceeds the cost of being caught by undercover legal officers. This is where the difference between this study and other trade studies lie, and perhaps this inherent difficulty is why there appears to be an absence of quantitative studies on the TCM trade.

Occupancy modelling:

Occupancy modelling is a research method applied to wildlife populations with the aim to estimate its occupancy parameters as a as surrogate for abundance (MacKenzie et al, 2002). One analogy commonly used to describe occupancy modelling is to take a snapshot of a population’s occupancy state to assess its current status (MacKenzie and Royle, 2005). The use of occupancy modelling can be extended to multiple seasons for the long-term study of a population’s local colonisation and extinction rates within a habitat. Occupancy modelling is an extension of presence/absence models, and aims to improve the accuracy of estimations derived from simple presence/absence data (MacKenzie et al, 2002, MacKenzie et al, 2006).

In presence/absence modelling, the occupancy of a site by a species is categorised into the binary states, ‘presence’ or ‘absence’. A species would be defined as ‘present’ on a sample site if one or more individuals were detected by researchers during surveys, logically non-detection then implies an ‘absence’ of species on the sample sites. While presence/absence surveys make an accessible research method for population studies, there is a flaw with such a simplified definition of occupancy; Even though detection of a species proves its occupancy on a site, absence can, in fact, be due to either the true
absence of a species, or the difficulty in detecting individuals in its habitat; the latter being a factor neglected in presence/absence models.

The strength of occupancy modelling lies in its ability to internalise uncertainties in the ‘absences’ recorded to minimise potential negative bias, while retaining the effective binary system of presence/absence modelling. This is achieved by the inclusion of detectability into models through repeat surveys to improve the accuracy of perceived ‘absences’. Researchers can estimate the probability of detection \( (d) \) by the equation: \( d = 1 - (1 - p)^K \), where \( p \) is the independent per-sample detection probability of each survey, and \( K \) is the number of repeated surveys. By adjusting \( K \), researchers can maximise \( p^* \), the probability of detecting a species at least once in \( K \) number of surveys, thus eliminating false absences.

**Assumptions of occupancy models:**

Like all scientific models, occupancy models work under certain assumptions that should be fulfilled by survey design:

1. **Population closure** – Population closure describes a timeframe within which a population is isolated from changes that would affect the species’ occupancy on sampled sites, i.e. during the survey period, sites that are observed to be ‘occupied’ (i.e. presence detected) will remain occupied, and those unoccupied will stay unoccupied. An open population would imply changes in a sample site’s occupancy, which can falsely increase perceived presence, which negates the purpose of conducting repeat surveys to account for false absences. One effective way to eliminate such changes is to conduct surveys within the shortest timeframe possible while accounting for potential temporal heterogeneity. In wild population studies this is often defined within seasons and periods of time where no major fluctuations in population number (such as by births, deaths, and migrations) occur.

2. **Independent probability of detection** – Independence of detection probability \( (d) \) and per-sample detection probability \( (p) \) is one of the fundamental assumptions of occupancy models (MacKenzie et al, 2006); it implies that the surveying of one site does not affect the detection probability in another. In wild population studies this sometimes means sample sites have to be distributed across the studied habitat, separated by a sufficient distance so not to affect one another’s occupancy.

3. **Constant occupancy probability \( (\psi) \) and detection probability \( (d) \)** – Occupancy models assume that the occupancy across all sample sites are constant, and that any differences is explainable by covariates; the same applies to detection probability. Therefore occupancy studies should be designed with caution to take into account and eliminate any factors that may introduce heterogeneities that cannot be described by covariates.
These assumptions are relatively easy to implement in natural habitats, but to apply occupancy surveys in markets would require careful considerations. In the section below we go through the differences, and discuss in detail how survey design is adapted accordingly.

3. Methodology

**Site selection:**
This study focuses on the Qing Ping area of Guangzhou, where markets to be surveyed are known for their trade in TCM and potential availability of illegal wildlife products. Site selection is not only based on known presence, but the known congregation of ‘presences’ of species (products made of wildlife); this is comparable to studying ‘historic sites’ as described by McKenzie and Royle (2005). The term ‘historic site’ is used in occupancy modelling to describe sample sites where a species has already been previously detected. The selection of sites with known presence introduces a positive bias into occupancy model, and cannot be used to make inferences about populations and habitats on a broader scale. While in wild population studies the use of ‘historic sites’ is not the norm. For this study it is justifiable, and arguably essential, as the area of Qing Ping and the ‘populations’ within are the primary focus of this research. Results from this study are not expected to represent the extent of illegal TCM trade in other parts of China, or even other areas in Guangzhou.

The purpose of this study is to design a standardisable scientific method to monitor the illegal TCM wildlife trade that would otherwise be undetectable. By testing this the survey design in Qing Ping as a pilot, we will address the issues and limitations that come with applying occupancy modelling in TCM markets and assess its feasibility. In this context, illegal wildlife products in the area of Qing Ping is our target population, and each market where occupancy surveys are to be conducted in represents a sample population.

**Location:**
For this study the area of Qing Ping (QP) is represented by 5 different markets; Qing Ping Lu (QPL), Qing Ping Medicine Centre (QPYYZX), Qing Ping Yao Cai Market (QPYC), Qing Ping Dong Market (QPD), and H Market. Their relative locations are represented in figure 3.1.

Apart from QPL, which is a street with shops predominantly selling TCM, the other 4 of the 5 markets are individual buildings dedicated to the trade of traditional Chinese medicine. Smaller Asian markets (QPYC, H Market, and QPD) tend to have tightly packed stalls with their boundaries outlined by thin partitions or metal frames; whereas QPYYZX is built to the style of Western shopping malls with most shops physically separated from each other with walls. Shops in QPYYZX and QPL are more spacious compared to the other markets. It is known that some traders specialise in the trade of certain products, and
different floors of markets tend to be themed according to such specialisations. With that in mind, all stalls and shops in the 5 markets, regardless of their sizes and product types, will be collectively termed “stalls” below for uniformity.

Survey design issues in a market:

A human market is markedly different from the natural habitat of wild populations that are normally the subject of occupancy models. The detection process required is also atypical of occupancy studies in that detections are necessarily mediated by traders through sustained direct interactions. Here using Qing Ping as an example, we discuss issues that are unique to the application of occupancy studies in TCM markets, how these align with the assumptions of occupancy modelling, how these can potentially affect our survey method and data collection, and how we can adjust and incorporate these into our survey design.

Practical issues:

Recognition and Suspicion:

All researchers would be suspicious to traders, this is the reason why detection is imperfect. It is this base level of suspicion that we would like to estimate using occupancy modelling. To avoid changes in the level of suspicion is to maintain a constant detection probability, which is a vital assumption to occupancy models.

Traders tend to have very good memory, WCS-China researchers have been recognised in markets in the past. This led to suspicion on the traders’ behalf and affected subsequent survey efforts. Recognition is partly responsible for WCS South China Project’s reliance on
volunteers for their market surveys. Recognition is likely to be reinforced by the request for illegal wildlife products.

Asking openly for products of protected species is no longer a common sight in the market; nowadays the attainment of any product (and especially for multiple products) is through traders who have personal connections with buyers, not by questioning stall owners directly and openly in a market (Trader B, 2012). The activities of researcher would naturally draw attention.

In an attempt to standardise the survey method, researcher is advised to refrain from activities that may be considered abnormal, such activities include:

1. appearing in the same market repeatedly, looking for illegal wildlife products over a prolonged period
2. asking for an illegal wildlife product that does not fit the stall type if the stall specialises in one kind of product
3. systematically surveying all stalls
4. looking for different types of illegal wildlife products in adjacent stalls

Occupancy modelling-related issues:
Survey replications – Occupancy survey replications can be temporal, spatial, or conducted by multiple researchers at the same time depending on resource availability and logistical constraints (MacKenzie and Royle, 2005; MacKenzie et al, 2006).

In this study the necessary interaction between researcher and stall owners facilitates familiarisation between the two, which can either increase or decrease per-sample detection probabilities ($p$). This complicates survey design as recognition will then affect detectability if we were to conduct temporal replications. As a result of this, in order to carry out replications whilst avoiding recognition, spatial replications will be conducted instead of temporal. This means sample stalls will be clustered into sites, which are to be defined post-hoc according to the optimal number as suggested by MacKenzie and Royle (2005), with each stall considered to be a spatial subunit of sites.

Temporal replications are often favoured over spatial replications due to its comparative simplicity (Field, 2005, Mackenzie and Royle, 2005; Bailey et al, 2007). MacKenzie et al (2006), Kendall and White (2009), and Gullera-Arroita (2011) also put much emphasis on how to decide whether to sample with or without replacement. Although I agree with Guillera-Arroita (2011) that given the lack of mobility of our subjects and a low number of spatial subunits per sampling site (i.e. the maximum number of surveys and cluster sizes will be restricted by the number of units available in each market), sampling with replacement would be more suitable for analysis. But in our case it is simply not an option, sampling without replacement is simply inevitable.
**Optimal number of replications** - Simulating different occupancy probabilities ($\psi$) and per-sample detection probabilities ($p$), MacKenzie and Royle (2005) suggest an optimal number of repeats ($K$) that should be incorporated into survey designs to maximise $p^*$. If we were to optimise our survey design following Mackenzie and Royle’s suggestion, conservatively predicting that in the general area of Qing Ping, $\psi = 0.6$, and $p = 0.2$, we would aim for 10 survey replications per site. This implies an extensive surveying effort.

As a result of this, it is decided that researcher will use ‘exhaustive sampling’ (Kendall and White, 2009), i.e. all stalls in all markets will be surveyed in this study. I consider this to be the best approach to sampling in this situation for a number of reasons:

- To select sampling units probabilistically requires knowledge on the stall numbers and positions in all markets. This is difficult as not all stalls are clearly labelled or occupied in markets, and some traders have stalls that span across multiple units. Researcher will not be able to stand in markets to look for a stall without attracting attention and encouraging recognition.
- As a pilot study, it is important to examine what would be the best approach to sample in practice. Sampling exhaustively allows this study to address some of the practical limitations of occupancy surveys in a market.
- By sampling exhaustively to collect a maximum amount of data, we can perform a more comprehensive analysis post hoc.

As part of the analysis, stalls will be clustered according to the optimal repeat sample number in the analysis. For example, if $K = 3$, then stalls will be systematically clustered into threes, each cluster representing a single site.

**Definition of ‘presence’** – Barber-Meyer (2010) defines presence as the direct observation of animal parts or of products where the species and its parts can be identified, emphasising that the inclusion of processed products, such as pills and tonics (which may or may not be made with the actual animal parts) can lead to false presence being incorporated into the analysis.

While I agree with Barber-Meyer on the need to eliminate bias by false presence, unlike Berber-Meyer’s described scenario of tiger-parts trade in Sumatra, the Qing Ping TCM markets sell products in diverse forms. Understanding the diversity of available products, containing illegal wildlife ingredients or not, can perhaps provide insights into the demand for illegal wildlife products. Furthermore previous surveys by WCS-China (unpublished data) have observed a correlation between displayed objects (either in the form of decorative animal parts or in a less recognisable form) and the sale of illegal wildlife TCM products in its original form. In any case for the purpose of this study all products and their forms are recorded.

**Observer effect** – Under ideal conditions occupancy surveys should be conducted by multiple researchers whose skill in observing for an animal are trained to a similar level to
eliminate individual bias; such biases in individual researchers’ abilities are known as observer effects. But unlike occupancy surveys of wild populations, this study requires direct human interactions in order to detect for presence. Not only is this interaction between traders and researchers spontaneous (on the stall owner’s behalf), other aspects of a researcher’s individuality (for example, appearance, age, and experience) would also play a more influential role than in wild population studies. In this study, only one researcher is used to conduct surveys to avoid complications brought about by potential individual effect of volunteers.

Dealing with the assumptions of occupancy modelling:
Apart from issues mentioned above, in order to apply occupancy surveys in a market we must also understand how violations to the assumptions of occupancy modelling can influence analysis, and seek to adjust our method accordingly.

1. ‘Population’ closure – For this study, ‘closure’ should be defined within a period of time during which the number of traders participating in the illegal TCM wildlife trade, as well as the overall amount and availability of products, remain stable, with no sudden efflux or influx occurring in the market to deplete or replenish stock, affecting occupancy probability. Since we have no information regarding the turnover rate of wildlife products in the market, we have to define this market ‘closure’ period arbitrarily (and conservatively) as one week in each market.

2. Detection independence amongst detection histories and sites – This assumption can be difficult to fulfil in practice due to the use of spatial replications and exhaustive sampling; Interactions between researcher and traders will inevitably attract attention from other traders, and encourage recognition and suspicion. Certain models permit the relaxation of this crucial assumption by accounting for a lack of independence between sites (MacKenzie et al, 2006; Hines et al, 2010), but knowing the extremely low detection probability of illegal wildlife products and TCM traders’ sensitivity to undercover law enforcement officers, violations to this assumption must be avoided.

3. Constant occupancy probability and detection probability – Assuming spatial subunits of a site share a constant occupancy probability is unrealistic, and will likely introduce positive bias to our occupancy estimate while underestimating detection probability (Kendall and White, 2009). Here we assume that constant occupancy probability operates on a site level while each spatial subunit has an independent occupancy probability. This also works in alignment with the use of exhaustive sampling to ensure independent detection history (Guillera-Arroita, 2011).

To ensure that no changes in occupancy or detection probabilities occur during the study period, WCS South China Project has also been asked to postpone any reporting of illegal TCM stalls to avoid legal actions from officials which could alert traders. Because the
subject of this study is dependent on human behaviour, the survey design must also take into account potential heterogeneities that can be introduced by anthropogenic phenomena such as working hours and day-of-the-week effects.

Below is a detailed description of the survey method applied in this study, with the aforementioned issues taken into consideration to optimise survey design:

**Survey method:**

Survey was conducted between 15th May to the 5th July, 2012, spending no more than one week for each market (to fulfill ‘closure’ assumption). Surveys were attempted in all stalls in all five markets. As a precautionary measure to avoid recognition, survey routes (transects) were arranged so that researcher passed by each stall no more than twice over survey period unless all stalls in that area have already been surveyed. Only one researcher was used to minimise observer effects. To search boldly for illegal products of multiple protected species in random shops would be unusual; to justify the researcher’s behavior a background story of the researcher as a TCM trade middleman was devised to justify the unusual behaviours and search for various illegal wildlife products.

This study only investigated the trade in products of saiga (*Saiga tatarica*) horns and pangolin (*Manis spp.*) scales. Both are CITES-listed and nationally protected in China (WCS China Program, 2011). Skills in both observation and verbal communications (with traders) are required to detect products. Occupancy was defined as the direct observation of illegal wildlife products of each species in any form inside interviewed stall. For example in stalls where saiga products were observed but not pangolin scales, the occupancy of saiga would be 1, and pangolin 0. Characteristics of shops were recorded as potential covariates.

Stalls in Qing Ping opened from 0900 to 1800. From experience, between the hours of 0900 to 1100 and from 1730 to 1800 some shops could be closed or might be unprepared for customers, conducting surveys during these times may require a second visit, which would risk overexposure of the researcher, therefore surveys were conducted over the course of the day between 1100 to 1730 on all days of the week to prevent day-of-the-week effect.

**Sampling protocol:**

Due to time constraints and limited resources, only rough maps could be produced before survey commenced. These had the layout of each market and approximate unit numbers in each section of the market. Transects were assigned prior to each survey, and followed by the researcher to keep track of relative locations of each stall. By combining survey findings with these maps, details such as stall positions and covariates were later identified.
Sampling in some markets and areas became highly opportunistic due to the need to avoid recognition and suspicion. In order to provide a sampling structure that can be followed, it was established that researcher would survey the first stall of every transect. From then on if the survey succeeded in finding illegal wildlife products, the researcher would carry on with the stall immediately adjacent to the one just surveyed provided the owner of this stall appeared to want to engage in conversation. If the survey yielded no observation of illegal wildlife product or stall owner reacted negatively to the question (indicated by unwillingness to answer and signs of agitation), the researcher moved on to the next stall to the same side of the route, but only conversed if the owner initiated. If no conversation was initiated then the researcher would skip this stall, too, and the two opposite, and survey the next stall along that was likely to sell the product.

**Interview protocol:**

Although conversations between researcher and traders are in principal reflexive and circumstantial, a followable unified backbone structure has been developed. This is outlined as a flow chart in Figure 3.2a and 3.2b.

**Analysis method:**

Collected data will be analysed as a single season occupancy model. Data is analysed using the statistics program R.2.15.1. R is preferred for its flexibility. Analysis of occupancy modelling is performed with the R package ‘unmarked’. The analysis was performed in two parts. The first part sought to find out the effect of randomised spatial clustering with collected data, using a null model ($\psi(.)p(.)$) and covariates to be collected. Stalls were divided into clusters of 10, the suggested optimal replication number, as subunits of each site. Results of each product found in market is analysed separately, so to obtain separate parameters for each product. This process is repeated for 1000 iterations.

The second part of the analysis examines the effect of cluster sizes on occupancy parameters. The same process as described for the first part of analysis is used, except stalls were clustered according to $K$, the number of replications to be determined in analysis (2, 3, 5, 7, 9, and 10).
Figure 3.2a. Interview structure of survey (to be continued on next page)
Figure 3.2b. Interview structure of survey (continued from previous page)
4. Results:

Surveyed concluded on 5th July, 2012. The number of stalls surveyed in each market has been summarised in table 4.1. Number of stalls surveyed varied amongst markets. The most thorough survey was conducted in QPL, where 81 stalls of the 91 available units were surveyed. This was due to the simplicity of layout of street, two parallel lines of units where traders were spaced too far apart to observe each other or listen to the conversation between trader and researcher. The third floor and fourth floor of QPYYZX were the most thoroughly surveyed, Fourth floor had many occupied stalls, hence a lower percentage (table 4.2). A large proportion of stalls in QPYC, QPD, and H Market were not sampled due to necessity for opportunistic sampling. H market was abandoned from occupancy surveys and excluded from study after day 1 of survey due to suspicion and recognition.

<table>
<thead>
<tr>
<th>Market</th>
<th>Available Units</th>
<th>No. of stalls surveyed</th>
<th>Percentage surveyed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPL</td>
<td>91</td>
<td>81</td>
<td>89.01</td>
</tr>
<tr>
<td>QPYYZX</td>
<td>500</td>
<td>192</td>
<td>38.40</td>
</tr>
<tr>
<td>QPYC</td>
<td>378</td>
<td>50</td>
<td>13.23</td>
</tr>
<tr>
<td>QPD</td>
<td>191</td>
<td>69</td>
<td>36.13</td>
</tr>
<tr>
<td>H Market</td>
<td>282</td>
<td>30</td>
<td>10.64</td>
</tr>
</tbody>
</table>

Table 4.1. Summary of survey results: Number of stalls surveyed in each market during survey period. Note that some stalls occupied more than one unit, and some units were not occupied at the time of survey.

<table>
<thead>
<tr>
<th>QPYYZX floor number</th>
<th>Number of stalls available per floor</th>
<th>Number of stalls surveyed per floor</th>
<th>Percentage surveyed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>123</td>
<td>49</td>
<td>39.84</td>
</tr>
<tr>
<td>3</td>
<td>136</td>
<td>70</td>
<td>51.47</td>
</tr>
<tr>
<td>2</td>
<td>145</td>
<td>41</td>
<td>28.28</td>
</tr>
<tr>
<td>1</td>
<td>96</td>
<td>32</td>
<td>33.33</td>
</tr>
</tbody>
</table>

Table 4.2. Summary of survey effort per floor in QPYYZX

Missing data:

As table 4.1 summarises, not all stalls were ‘surveyed’. While in theory thorough data collection across all stalls on predefined transects is possible, in practise this was not so. Stalls differed in sizes and arrangements according to different markets, such variations in stall sizes and market openness restricted the number of stalls available for survey. Where stalls were spacious and isolated (i.e. where traders operated in shops) the researcher was able to consecutively survey stalls while maintaining independent detection probability as stall owners were less likely to notice the abnormal and exhaustive effort of the researcher, and their reactions to the request for multiple products had no observable impact on subsequent surveys. However in smaller markets, stalls were closer together and lacked physical separation; Stall owners tended to observe and communicate with each other throughout the researcher’s interviews. To thoroughly survey every stall available
would raise suspicion, and risked exposing the researcher’s identity to not only the owner of the surveyed stall, but also traders of neighbouring stalls, affecting the independence of detectability amongst sites. As a result researcher needed to avoid thorough sampling, and resorted to opportunistic sampling.

Where market units were arranged according to product type, opportunistic sampling also had to be applied. Floors of multistorey markets tended to have their own themes. For example the majority of stalls on the third floor of QPYC sold only ginseng. For an unfamiliar customer to ask for an illegal product that had no relevance to the products sold by the rest of the floor would likely alarm traders. Once again survey had to bias towards the sampling of stalls with particular characteristics.

H market, where stalls were smallest and least isolated of all markets, was abandoned from this study as a result of overly thorough surveying effort. The researcher attempted to survey all stalls along a transect, but interviewing stall owners across 15 successive units searching for multiple products prompted recognition and raised suspicion amongst traders. This led to following surveys to being interrupted by previously interviewed stall owners through subtle signalling using physical gestures, or direct verbal communication. The researcher’s identity was exposed and stall owners within the area became aware of a suspicious customer. Ultimately traders refused to speak to the researcher, who was forced to abandon the survey to avoid personal risk and the possibility of compromising surveys in other markets. This incident highlights the limitations of applying occupancy surveys in a market; the trade-off between the need to collect a sufficient amount of data, to maintain methodological consistency, and the need for opportunistic sampling to ensure overall survey success.

In addition to thorough surveying, researcher also found out that searching for pangolin scales and saiga horn products at the same time was considered unusual (in many occasions researcher was questioned or met with negative reactions). In TCM, these products had very different medical properties. In smaller markets the request for both products would raise suspicion, therefore the researcher had to ask only for whichever product seemed most likely to be present. This was yet another potential bias, which meant some stalls lacked data for one of the two focal species.

**Products of focal species:**

Overall four types of products were observed in the markets. Two of these were made of pangolins. These were unprocessed pangolin scales and fried pangolin scales. Unprocessed pangolin scales came only in one form, whereas fried pangolin scales could be found in a variety of forms, ranging from 3000yuan to over 6000yuan depending on the quality of product. Scales could be ‘fried’ with water, or with salt and sand, the latter would be the lower-quality product as the processing would make fried scales heavier, increasing the weight of product thus increasing the profitability to trader. However apart from the price differences, fried scales of different quality were indistinguishable; traders also tended
to change the price at will. Due to the inability to differentiate between these products, all fried pangolin scales were therefore regarded as the same.

Saigas products also came in two forms; horn shavings and whole horns. Horn shavings may be thick slices or thin shreds, neither of these were easily identifiable on a species level. In fact there were occasions when traders would claim one bag of unlabelled horn shavings to be made of buffalo and another as saiga horn shavings, when researcher could not differentiate the two by sight or smell. Saiga horn shavings were being sold from 680yuan to over 1600yuan per kilogram (kg). Whole horns price ranged from 20000yuan to 32000yuan per kg, and were priced according to a three criteria; age, condition, and weight (table 4.3).

<table>
<thead>
<tr>
<th>Age -</th>
<th>Horns of younger saigas were considered more effective, this was judged by the size and weight of the horn, as well as the number of ridges along the horn. Younger horns also tended to have black tips.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition -</td>
<td>The freshness of a horn was also a determinant of price. Horns would tend to crack along the base over time, and these would be sold at a lower price. Some traders would polish and smoothen the surface, others kept horns in freezers to retain bloodstains or attached skin. On one occasion one trader painted a saiga horn with nail varnish to hide cracks. This shows how important condition is as a product quality.</td>
</tr>
<tr>
<td>Weight -</td>
<td>Most products in a TCM market was sold by weight. Since only the keratin on the surface of saiga horns was considered medicinal (pers. communication), horns that had their bone cores removed were sold for higher prices.</td>
</tr>
</tbody>
</table>

Table 4.3. Pricing criteria for saiga horns in TCM market

Identified covariates:

Part of the study’s aim is to identify covariates in the market. Three covariates were identified during survey. These affected different parameters of occupancy modelling:

Covariate 1. Market type:

QPD, QPY, and H Market were identified as “small Asian markets” (S), whereas QPL and QPYYZX were given the covariate “Westernised mall” (W).

The differences between the two market types are defined as follow: “small Asian markets” tend to have closely packed smaller units (note however that one stall can occupy more than one unit), each covering an area less than 3 meters (m) by 3m with most corridors being less than 4m wide, Stalls are divided by thin partitions or metal frames. As a result of this lack of space in each unit, stall owners tend to sit outside their stalls.

“Westernised mall” describes markets where the majority of stall units are larger than 3m by 3m in area. Stall units in these markets tend to be spacious and are physically separated from each other, with most corridors being more than 4m in width. This accurately describes both QPYYZX and QPL (even though QPL is a street market).

Market type as a covariate influences both occupancy and detection probabilities. Occupancy probability of our focal species may differ in markets due to potentially varied
target markets with different demands. For example, traders in smaller Asian markets tend to be more willing to bargain and sell their products at a lower price (pers. obs.). Market type also affects detectability; Due to the differences in stall sizes and units arrangements, interviews in smaller Asian markets lacked privacy as neighbouring stall owners often listened in. This transparency in the researcher’s actions amplified the effect of recognition and suspicion, limiting researcher’s ability to survey stalls thoroughly.

Covariate 2. Stall type:

Traders in Qing Ping often specialise in different types of products. From personal observation, the diversity of stall type can be grouped into six categories. Table 4.4. and Table 4.5 show that general stalls were the most common category, and market had a similar mix of different stall types.

<table>
<thead>
<tr>
<th>Stall type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animals</td>
<td>These shops sell a mix of animal products. With the majority of them being made of dried reptile parts, including turtle carapace and plastrons, snake skins, dried crocodile meat, and dried whole geckos. Dried arthropods such as scorpions, centipedes are also common amongst stalls in this category.</td>
</tr>
<tr>
<td>Deer products –</td>
<td>Shops in this category sell primarily deer products such as sliced antlers, deer tendons, deer embryos, and deer penises. Some also sell powdered or shaved bones, and horns of unspecified species.</td>
</tr>
<tr>
<td>General</td>
<td>This category is inclusive of all stalls where specialisation, as defined here, is not immediately obvious from its name or by looking at products</td>
</tr>
<tr>
<td>Herbal</td>
<td>In the context of TCM, ‘herbal’ medicine includes a wide range of ingredients, from plants to animal. Here the term ‘herbal’ is used to describe both plant- and fungi-based products, specialisation in the trade of citrus peels, ginseng (Panax spp.), or fungal species (ganoderma spp., cordyceps spp.) is very common</td>
</tr>
<tr>
<td>Swallow nest –</td>
<td>As the name suggests these shops sell mainly swallow nests, which are luxury goods. Other manufactured and pre-packaged products such as medicinal tonics are sometimes available</td>
</tr>
<tr>
<td>Dried seafood –</td>
<td>Shops within this category tend to further specialise in the trade of fish swim-bladders, fish gills, shark fins, seahorses, sea cucumber, and/or starfish</td>
</tr>
</tbody>
</table>

Table 4.4. Stall type: Categories and definitions

To traders, dried seafood and swallow nests are not considered to be TCM, and not all herbal stalls sold TCM ingredients, some sold only tea leaves. Although the specialisation of stalls suggests a narrowed range of available products, these specialisations were not strictly adhered to, some traders of specialised non-TCM products also sold illegal wildlife products of our focal species. The covariate ‘stall type’ is relevant to the occupancy probability of our target species and should not affect detectability as survey protocol aims to conduct a thorough survey.
Covariate 3. Animal product display:

From a preliminary survey conducted by WCS-China in March (unpublished data**), it was speculated that displays of decorative animal parts such as deer heads, horns, and antlers were used to signal a stall’s availability of the horn products made of protected species including saigas. Apart from decorative displays, conversations during surveys also revealed that traders would often display horn shavings without specifying which species it belonged to, as a subtle indication for horn-related illegal products.

When present, horn shavings or decorative animal parts is used as a conversation starter for researcher to initiate interviews, and engage traders to reveal the availability of saiga products. Therefore the presence of displays is identified as a covariate that affects only detection probability.

No such displays were found to be related to the sale of pangolin scales. As a result this covariate only applied to saiga products.

Occupancy data from markets:

<table>
<thead>
<tr>
<th>Market</th>
<th>Animals</th>
<th>Deer products</th>
<th>General</th>
<th>Herbal</th>
<th>Swallow nest</th>
<th>Dried seafood</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPL</td>
<td>2</td>
<td>0</td>
<td>65</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>81</td>
</tr>
<tr>
<td>QPYYZX</td>
<td>4</td>
<td>14</td>
<td>75</td>
<td>71</td>
<td>14</td>
<td>14</td>
<td>192</td>
</tr>
<tr>
<td>QPYC</td>
<td>1</td>
<td>2</td>
<td>26</td>
<td>10</td>
<td>5</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>QPD</td>
<td>5</td>
<td>3</td>
<td>58</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>69</td>
</tr>
<tr>
<td>H Market</td>
<td>2</td>
<td>0</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
</tr>
</tbody>
</table>

Table 4.5. Number of surveyed stalls within each category in the markets

Occupancy analysis:

The ability to analyse the complete set of collected data was limited. Both datasets from QPL and QPYYZX were comparatively comprehensive and sample was non-selective, but sampling in smaller Asian markets became highly opportunistic. Avoiding suspicion meant that the researcher either had to target stalls with particular covariates or skip a large proportion of units (table 4.1). Understanding the data’s violations to the assumptions of occupancy modelling, here we choose to neglect the analysis of data from smaller Asian markets. Instead we present a subset of occupancy analysis for presence of fried pangolin scales from QPL that highlights issues with the application of occupancy models in a market.
Only a null model ($\Psi(.), p(.)$) was used in the analysis, assuming constant occupancy and detection probabilities with no site covariates and observation covariates considered. For the site covariate stall type, both QPL and QPYYZX lacked stall diversity; there were only 2 and 4 stalls in the category Animals for QPL and QPYYZX respectively, which does not provide a sufficient number of replications for occupancy analysis. Both QPL and QPYYZX share the covariate ‘Westernised mall’ and there is no reliable data from any of the small Asian markets. Surveying in QPD, QPYC, and H Market also sampled non-randomly for stalls with a presence of displays.

**Part One – Effect of randomised clustering:**

To begin with, occupancy analysis was performed on the most complete set of data, QPL where 89% of stalls were surveyed. Clusters of 10 (as suggested by MacKenzie and Royle (2005) for our presumed $\Psi$ and $d$, 0.6 and 0.2 respectively) were grouped randomly for 1000 iterations, with estimates for parameters $\Psi$ and $d$.

By randomising the clustering of stalls ($K=10$, $s=8$), we can see that the mode of occupancy is 1 (figure 4.1b). This is likely due to the relatively high naïve occupancy of fried pangolin scales in QPL (table 4.6), which under random distribution across sites means most sites have at least one detection. We can also see that when detection probability is high, occupancy probability is low and vice versa. This is a trade-off between site number and replication number. In cases where detection probability is conceived to be high, detections occur repeatedly in particular sites but in exchange more sites fail to detect any presence, leading to a lower occupancy estimate (figure 4.1a).
Occupancy modelling aims to improve the accuracy of the estimates for both parameters by repeat surveys, but when the number of sites are limited, another trade-off between occupancy and detection probabilities occurs with the increase of replications. Consider the following equation for total number of surveys (TS) (MacKenzie and Royle, 2005):

\[ TS = s \times K \]  

The denotation \( s \) refers to the number of sites, and \( K \) to the number of replications. Given a limited number of total surveys (i.e. available surveyed units), although increase in replications would improve the accuracy of detection probability estimates, the accuracy of occupancy estimator decreases accordingly due to a lower number of surveyed sites. With a fixed total number of surveys, an increase in \( K \) results in a decrease in \( s \). This trade-offs between site number and replication number has been the subject of discussion by many authors (MacKenzie and Royle, 2005; Field et al, 2005; Bailey et al., 2007), with the general opinion favouring the use of temporal replications over spatial replications.

Regardless of the number of survey repeats, without accounting for any site and observation covariates, randomised spatial clustering provides little reliability to occupancy analysis and has little relevance to studied populations. This is clearly demonstrated in fig. 4.2, where a similar pattern for the distribution of occupancy and detection estimates is observed across all replication numbers.
5. Discussion:

In the following section, we discuss some of the weaknesses of the design of this survey, what insights we have gained from this pilot study, how and what else can be done to improve the survey design. We will also critically examine the use of occupancy surveys in this particular scenario, the TCM market.

Difficulties with data analysis:

Results from our analysis show that occupancy estimates from randomised spatial clusters provide little insight into the true extent of the TCM trade. The lack of diversity means some stall types will be limited to one site with 2 replications (e.g. fried pangolin scales in QPL). Analysis using models fitted with covariates is unlikely to be reliable. Another possibility is to cluster by proximity, but spatial replication in this case relies on the arbitrary
grouping of stalls into clusters as repeat units. The estimators of occupancy and
detectability will therefore be reliant on the arbitrary number of optimal repeats, and which
stalls were perceived to be within proximity of each other. This is not statistically robust.
The analysis of our data is hindered by how sites are defined.

Possible improvements:
Perhaps one possible way to move forward our analysis is to adopt Hines et al’s
(2010) advice, and investigate possible spatial dependence at different cluster sizes.
Hines et al (2010) describe the development and use of a new model that
incorporates Markov processes such as spatial dependence, which accounts for spatial
dependence biases from occupancy surveys conducted along forest trails. In Hines et al’s
study, spatial dependence is suspected due to the use of transect segments as spatial
subunits without replacement. Our study also utilises transects but unlike forest trails, our
sample subunits (stalls) are individual entities; occupancy is unlikely to be continuous and
may have substantial covariate differences. Nonetheless it is perceivable that traders could
influence each other’s decision on which product to sell. Through the use of this model we
can identify whether spatial dependence exist; and if it does, at which replication size spatial
dependence diminishes. We can then define sites non-arbitrarily according to this suggested
number to provide a better form of clustering for analysis.

It must be noted that while the scenario proposed by Hines et al (2010) bears
similarities with surveys conducted in TCM markets, it should not be confused with a lack of
survey independence that has been observed in our study. In Hines et al’s (2010) case (and
Kanranth et al (2011), where the model is applied to tiger occupancy surveys) the increase
in subsequent detection probability is due to tigers’ continual use of path, which the survey
transect follows, this resulted spatial dependence is occupancy-related. Whereas in our case
we have observed traders responding according to their neighbour’s decision thus affecting
the subsequent survey results, the change in this case is due to Markovian process in
detection probability, i.e. detection dependence. While we are fully aware that such change
in detection probability has occurred in smaller Asian markets, it is unclear whether the
same happened in Westernised malls. To examine whether this bias exists in our data, the
trap response model (also developed by Hines et al (2010)), which accounts for Markovian
dependence on detection probabilities may be applicable.

Issues with the application of occupancy modelling in TCM markets:
I believe in terms of producing a standardised protocol for conducting occupancy
surveys in a market; although this pilot study has been plagued with practical issues, the
insights to limitations can be used to improve the survey design. With sufficient resources, it
is possible to have a repeatable survey structure.

The lack of survey independence however is one of the major violations to the
fundamental assumptions of occupancy modelling. In fact from the piloting of occupancy
modelling in Qing Ping, I have noticed a number of issues that undermines the applicability and reliability of occupancy studies in this context. Here I outline these issues and discuss how they can be overcome, and how these would affect the study if they cannot be resolved.

Sample selection:

The use of opportunistic sampling has been mentioned throughout. It is indeed important to acknowledge that sampling biased towards stalls that were easier to survey (‘Westernised mall’), those with a presence of ‘display’, while avoiding stall types that were not normally associated with illegal wildlife products such as ‘Herbal’ and ‘Seafood’. By preferentially selecting for stalls that were perceived to have higher occupancy probability and higher detection probability, a potential positive bias could be introduced and lead to an overestimation of the perceived abundance of illegal wildlife products.

Replication:

The design of this study can be improved in two ways for future studies. One is to ameliorate the use of spatial replications following the advice of Kendall and White (2009) and Guillera-Arroita (2011). Realistically it is unlikely that stalls within the same cluster will have equal probability of selling illegal wildlife products, and it is difficult to perceive our subjects of interest having a mobility so high that occupancy can be assumed independent (Guiller-Arroita, 2011). I suggest we adhere to sampling without replacement, but the clustering can be improved using Markovian process models for spatial dependence or detection dependence.

While the difficulty in analysis was in part due to difficulties with determining a meaningful definition for site, the practical constraints of survey also played a major role; namely the lack of detection independence in smaller Asian markets. Therefore another way to improve upon survey design is to circumvent recognition by the use of multiple researchers to utilise temporal replication. This will likely introduce observer effect, but this can perhaps be accounted for as a covariate.

In fact despite in theory observer effect is kept to a minimum in this study as only one researcher conducted surveys, in practice a trader’s familiarisation with researcher by observation can also influence detection. Without the influence of recognition, surveys in smaller Asian markets can perhaps be conducted more thoroughly to obtain reliable data. The key issues with using multiple researchers to detect for illegal wildlife products within such a short closure period is that it can raise suspicion or increase perceived demand. The former will affect detection probability, while the latter not only raises ethical issues, but more importantly it is counterproductive for the conservation of our focal species.

Difficulty in defining occupancy:

Occupancy as defined by direct observation of a product was perhaps too simple a definition. In hindsight ‘presence’ of illegal wildlife products in TCM market was much more
complex. In wild population studies one would only observe what exists on the site, but in markets the presence of one species could be from a different stall or even market.

Due to legal pressure and routine inspections, most traders no longer kept illegal wildlife products inside their stalls, but at a separate location, such as another stall owned by the trader in a different market. Even if they had the products in-store many would rather unfamiliar customers not see where they kept their secret stock in fear of undercover journalists or inspectors, and opted to show products brought in from somewhere else. Therefore observed products could be brought from (or the researcher can be brought to) a different site that may or may not belong to the same market. This is perhaps the biggest misalignment between the two scenarios.

On occasions researcher was brought to another stall where the product was known to exist. Upon survey the two sites connected; the survey was conducted in one stall while species was observed in another. We may not be able to combine both shops as they may have different covariates or are from different markets. Where and how do we define presence in these cases? Note that this also has implications for detectability; as researcher was redirected to another stall, surveying in one affected the detection probability of another (detectability in the other stall became 1). Detection was clearly not independent. In cases where products were brought to the stall, even though the interview succeeded in observing said products within the site, in reality this was arguably no different from the former scenario as the specimen was not strictly ‘occupying’ the site.

To further complicate matter, many traders owned stalls across all markets to maximise profit, others share the same stockpile of product, which blurred the definition of presence in occupancy surveys as the researcher could be looking at the same sample product from the same stockpile in a number of stalls, and occupancy is suddenly transferrable amongst unrelated sites.

It is obvious that many of the basic assumptions and theory of occupancy cannot be realistically fitted into a TCM market. Given such low reliability, it is important that we carefully consider what conservation can gain from applying occupancy modelling in TCM.

Conclusion:

Monitoring vs. Management:

Having reviewed the effectiveness, practical issues, and reliability of data, it is apparent that the application of occupancy modelling in TCM markets is not the most feasible monitoring method. Resource allocation is essential to successful conservation projects, and has been discussed by Possingham et al (2011); their argument is based on two key points. Firstly, can monitoring inform future conservation action and policy? Secondly, can the application of monitoring justify the trade-off with other management actions?
Here I would like to address these questions and evaluate whether the application of occupancy modelling is best to study TCM trade.

Although occupancy modelling can provide an estimate for detectability, and inform us how much of the trade is not detectable. How will this information inform future actions? Can estimating the proportion of undetected illegal wildlife products in market tackle demand?

The closure assumption of occupancy modelling would necessitate the use of volunteers which multiplies the cost of monitoring. Would this resource not be better spent on other management or monitoring actions, such as assessing the effectiveness of legal enforcement, or education campaigns? In my opinion, to monitor the effectiveness of legal enforcement is more informative of future management actions than obtaining insights to the extent of the trade.

As for the trade-off between resource allocation; anecdotal evidence obtained from interviewing traders suggests that the TCM trade is adapting to technology. On many occasions during interviews, traders mentioned that due to the legal enforcement pressure on the markets, many have branched out to the Internet trading of TCM products.

Furthermore it was revealed that some traders are attempting to stockpile products. Their notion is to continue the exploitation of wild populations for illegal wildlife products, until species becomes overexploited to extinction (or extinction in the wild depending on whether there is technique for captive breeding). Because in achieving extinction, traders would not only be able to monopolise the market, the rarity value of their products would sharply increase their profitability. In this case, would addressing the demand in TCM markets help with the continual exploitation of wildlife?

In the light of this information we must remind ourselves what is the aim of our action? It seems to me that the most effective conservation in this scenario is not to monitor the trade, but to implement actions that can address the source of the problem, which is demand, though education and awareness campaigns, and ensure effective legal control through local capacity building.

6. References


Trader A, (2012) Personal Interview with Y.K.J.Lam, 29th May

Trader B, (2012), Personal Interview with Y.K.J.Lam, 15th June


WCS China, (2011), 2011 Wildlife conservation society China program


7. Appendices:
The following is the raw data collected from QPL. Other sets of data are omitted as these were not analysed due to lack of statistical reliability time constraints

<table>
<thead>
<tr>
<th>stallno</th>
<th>stalltype</th>
<th>display</th>
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<th>p.fried</th>
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