The biodiversity governance in Xinjiang China Liquorice management as an example

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1 An Introduction to the Problems of Medicinal Plants in Xinjiang

The problem of the management of medicinal plant harvesting and processing is an important one in Xinjiang. Medicinal plants have long been used in traditional Chinese medicine, and much of the harvest has occurred on traditionally managed lands in customary harvesting practices. The changes in the global trade of these plants and the changes in the Chinese economy have combined to place new pressures upon these plants and their processing. These pressures have resulted not only in the rapid decline of resource stocks (an economic tragedy for the industry) but also in the rapid degradation of many of the lands on which they were harvested (an environmental tragedy for the society).

In our analysis of the problem and the policies required to address it, we attempt to look at both the economic and the environmental aspects of the problem. We do this by examining the problem of medicinal plant harvesting in Xinjiang as a vertical industry comprised of land managers and plant harvesters/managers. And then we look at how regulators and regulations interface with this industry, overall and at various levels. We are asking the questions: How does the special situation of property rights ambiguity in Xinjiang impact upon the sustainability of this production process? And, how can government management address the problem of the sustainable management of the liquorice industry, when the underlying property rights problems (in land and in liquorice) is managed separately?

The remainder of this first section introduces Xinjiang and its liquorice industry. It provides a brief overview of the plant, its significance in the

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domestic and international market, and the problems it faces. This section also introduces the regulation system that governs its use and the property rights problems that afflict the lands on which it is raised. Finally we outline how the remainder of the paper will go about addressing the issue.

1.1 Liquorice Overview

This paper is about wild medicinal plants management in Xinjiang, China. Xinjiang is located in northwest China, covering around 1/6 of the whole country's area. Its geographic location in Central Asia gives it a diverse biosphere with over 4000 wild species that are unique to Xinjiang. Many of these species are used in Chinese medicine. The classic Chinese pharmacopoeia, Compendium of Materia Medica, which is over 500 years old, states that there are 2014 medicinal plants used in Chinese medicine. One of these is liquorice, a popular herb used across the globe for a variety of purposes.

There are 16 species of Liquorice (Glycyrrhiza genus, Gan Cao in Mandarin) in Xinjiang. A few examples of the strains of liquorice used in medicine are: G. uralensis, G. glabra, G. inflata, and G. aspera. G. inflata grows in Southern Xinjiang, while the other species grow in the moister and cooler northern Xinjiang. Liquorice is considered to be one of the 50 fundamental Chinese medicinal herbs, and is known as "the king of Chinese medicine". Liquorice can aid physical relaxation, and provides cough relief. Its extract is widely used in modern medicine, such as cough syrup. It is also used in conventional and naturopathic medicine for oral and peptic ulcers. Liquorice is also a mild laxative and may be used as a topical antiviral agent for shingles, ophthalmic, and herpes. More recently, liquorice extract has been used for autoimmune conditions including lupus, scleroderma, rheumatoid arthritis, and animal dander allergies.

Due to this wide variety of uses, liquorice root is used in natural health products in East Asian countries such as Japan and South Korea, as well as in Chinese cuisine. Liquorice extract, which is more than 50 times sweeter than sucrose, is used as a food additive sweetener. For example, liquorice flavouring is used in soft drinks and in some herbal teas, where it provides a sweet aftertaste. The flavour is commonly used in medicines to disguise unpleasant flavours. It is also popular in the Netherlands and Southern Europe. Liquorice is commonly used to flavour, sweeten, and condition tobacco products to add a mellow, sweet woody flavour.

Liquorice has more than just economic value. It is also important in preventing sand and soil erosion in the dry, arid areas of northwest China. Exploitation of liquorice and other herbs has led to desertification and sand

storms. Increasingly large amounts of grasslands have become deserts, and devastating sandstorms now occur more frequently, and for longer duration . It is estimated that for each kilogram of unearthed liquorice root, 20 square kilometers of land suffers from soil erosion. Due to its importance in the local ecosystem, saving liquorice from extinction is important not only for medicine, but also for environmental conservation.

Many traditional medicinal plants are used widely in the pharmaceutical industry. Scientists can now use chemicals to synthesize a limitless supply of compounds, and quickly produce medicines on an industrial scale. However, the pharmaceutical industry still has an interest in raw plant chemicals because many of the active compounds produced by plants are very difficult to synthesize.

In recent years, the liquorice plant in Xinjiang has been vastly mismanaged and the supplies of the plant have been in decline for several decades. Due to a lack of effective regulation, liquorice has been overexploited over the last half century– a rather short period when compared to the long history of its use in China. One of the puzzles of liquorice exploitation is how it has come to be in such a perilous predicament after such a long history of use and management. What has changed to result in this situation?

1.2 History of Grasslands and conversion

One aspect of liquorice management that has been dramatically altered in recent decades is the system of property rights that are in place in China. The Constitution of the PRC secured all rights in land to the state in the initial charter. (Ng 2008) This ushered in a period of grassland management in the form of collectives and collective management. More recently, there has been a movement away from collective management and toward the issuance of government-issued contracts in land holdings. In either instance the underlying rights in the land remain in the state, but in former times the local community managed those rights in common while more recently the rights in lands are assigned by long-term contracts to individuals and corporate entities. This change in underlying land ownership has resulted in a shifting in land management and use.

Two sub-periods of liquorice reduction can be identified, with the first period being between the 1950s and 1970s when extensive land conversion from grassland into agriculture farmland was encouraged by the central government. This converted the land on which liquorice traditionally has grown. It was estimated that over 800,000 hectares of land was converted into cultivated land during that period (Ding, 2003). Conversion has continued since

that time but at a reduced pace. The second period, between 1980 and 2000, witnessed the rising international popularity and industrial use of liquorice, and the accompanying increase in economic value.[1]

In addition the conversion of water resources has also contributed to herbal resource decline in Xinjiang. Cotton and other plantation crops require much larger allocations of water than did previous dryland crops. This conversion of the land to these crops has resulted in an increased scarcity in water supplies available for all other uses. In one fifteen sq km area in Xinjiang, 5 out of 15 lakes have completely dried up, and another 5 have shrunk. The overall surface area of lakes in this region is currently half of previous levels in the 1950's. In the downstream section of the Tarim River, whose water supply has largely been cut off, over 2 million mu of liquorice plants have died. The allocation of scarce water supplies to other crops and uses is clearly cutting down on the availability of water to these herbal resources.

The allocation of water and land to other uses has made a very severe impact upon the availability of these resources for the supply of liquorice. This conversion process has been generated by the development process occurring across Xinjiang, and the change in property rights allocations (to water, to land) in that province.

1.3 Use of Liquorice and the liquorice industry

China is one of the largest suppliers of liquorice roots and extracts in the international market. China possessed 4-5 million tons of liquorice root reserves in the 1950s. between 1980 and 2000, witnessed the rising international popularity and industrial use of liquorice, and the accompanying increase in economic value. Excessive digging and international trade significantly reduced these resources to around 350,000 to 450,000 thousand tons by 1983. Although restrictions on exports were imposed in 1983, 170,000 tonnes of liquorice were exported over the next ten years. As a result of

[1] China is one the major suppliers of Liquorice roots and extract in the world, especially to the East Asian countries such as Japan and Rep. of Korea. Although restrictions on exports were imposed in 1983, the total exports for the period of 1982 to 1993 still reached 170 thousand tons. As a result of large-scale extraction, the natural reserves of licorice root are now less than 40% of the 1983 level. Although the trade department planned annual exports of only 3700 tons of licorice root, more than 10,000 tons were sold abroad each year in the 1980s. According to data from United Nations Statistics Division, China's share in export market was nearly a half in the first half of 1990s and cut down to around one third in the second half. The drop was due to the fact that China started export quo permit for Licorice in 1994. However, as a result of the elimination of export quotas on licorice root in 1999, the export amount rose sharply again in the year 1999 and 2000, one year just before China joined WTO (Zhao, 2007). After that, this figure keeps at a level of around one fifth since 2000, with the absolute quantity at around 3000 tons per year.

large-scale extraction, the natural reserves of liquorice root are now less than 40% of what they were in 1983. Although China's quotas in the 1980's only allowed 3,700 tonnes of liquorice root to be exported each year, more than 10,000 tonnes were sold abroad each year during this period.

Though Xinjiang's individual export rate is unavailable, the natural stock has shrunk dramatically. It was estimated that in the 1950s there were approximately 3.5 to 4.5 million tones of wild liquorice roots, with 1.5 to 2 million hectares of land devoted to the growth of the plant. By 1986, only 866,700 hectares were devoted to growth, and liquorice root reserves dropped to 1 million tonnes. In 2001, only 562,400 hectares of land was left covered with liquorice root with a mere 0.65 million tons of reserves remaining. By 2001, the acreage had decreased by 68% since the 1950s, and the reserve had dropped by 84%.

Due to the interaction between unstable global demand and supply, the price of liquorice roots in the world market varies greatly. The price soared in the early 1990's when the United States began importing large quantities. However, after reaching its peak in 1993, the price began declining. Following a few fluctuations in the mid and late 1990's, the price since 2000 has steadily risen, signalling the shortage of the worldwide liquorice supply relative to the increasing demand. Price variation in the 1990's makes it difficult for farmers to predict the price in the near future. From the perspective of farmers, it is also difficult to make cultivation plans because liquorice takes three to four years to mature.

1.4 Permit System

In the 1980's, over 30 companies produced Liquorice extract, which annually consumed 120,000 tons of liquorice grass and the entire industry was unmanaged. By 1999, the central government strengthened regulations on Liquorice extraction and shut down several particularly environment-damaging plants. Currently, there are only 4 or 5 firms that make liquorice extract directly from roots, compared to over 30 firms in the 1980's. The system, which is still in effect, controls zoning and manages the issuance of harvest, purchase, and transportation permits. Transportation permits are necessary to transport wild plants outside Xinjiang. Individuals or companies wishing to harvest liquorice on a certain plot of land must first obtain permission from the grassland contractor who has contracted the land from the government. They are only allowed to harvest that particular area during the specific liquorice harvesting season, from October to April. Wholesalers and processors must apply for and obtain purchasing permits in order to buy liquorice for processing. Those attempting to transport herbs out of Xinjiang must

present a transportation permit at toll-gates. All of these permits are issued annually, can be used only by the applicant, and are not transferable.

Despite the rigid design of the quota and permit system, monitoring and enforcing the system is challenging. Harvesting without permits, picking in excess of a quota, and cross-border harvesting all occur regularly. According to a 2003 interior document from the Animal Husbandry Office of Xinjiang, only four wholesalers out of 59 in the province applied for purchasing permits when the quota system was introduced in 2000. Adherence to the permit and quota system is still largely ineffective in preserving wild liquorice. This is due to a number of factors, such as poor management and lack of funding. While the national government creates grassland law that provinces then adopt, it is mainly the provincial and city-level authorities that monitor and manage the grasslands. In particular, the provincial and city level Grasslands Monitoring and Supervision Stations ("GMSS") handle applications and physically monitor their regions. These offices are often understaffed and lack resources to effectively manage their areas.

According to the Ministry of Agriculture, in 2005 there were 1,637 cases involving illegal harvesting of wild herbal plants in China, which is 31% higher than 2004. This figure fell to 1,095 in 2007, but is still 40% higher than in 2006 . The high market price of these plants, coupled with relatively mild punishment, drives many people to risk illegal activity. For example, the domestic wholesale price of high quality herbs has risen in the past few years from 15 yuan/kg to 17 yuan/kg. This combination of increased harvesting incentives with lack of inspection and monitoring capacities results in poor enforcement of the harvesting regulations.

1.5 Analysing Medicinal Plant Problems - Outline of the Paper

The problem of liquorice is typical of the problems faced by biodiversity in many parts of the developing world. It is a problem of rights allocation, a problem of development and a problem of governance.

First, the original biodiversity is being impacted by a change in rights holdings in the country in some of the basic resources that support the biological system - the rights to lands and the rights to water. These rights are now being allocated to different decision makers than those who have controlled land use and water use in Xinjiang for many hundreds of years before.

Secondly, these decision makers are then helping to move Xinjiang out of traditional cultivation practices and toward the re-allocation of resources

toward different development paths. This is consistent with the general development of the region, but it also occasions a lot of change in the availability of resources to support the traditional system. Agricultural development requires re-allocation of land and water and this necessarily implies the loss of much of the previously sustainably managed biological resources.

Finally, the problem is one of staged decision making by the government, in which it attempts to deal with a dying system through managed flows. The increasing and impending re-allocation of lands toward other uses gives notice to the existing managers of liquorice that there is little incentive to manage sustainably - the government's continued conversion of land provides an ongoing flow that appears unsustainable. And optimal management of a flow of a nondurable good that is being converted will look like a management problem. For this reason governance of an industry in decline will necessarily look like ineffective management, when in fact it is simply channeling the supplies that result from conversions.

These are the points we wish to make in this paper. First, conversion dictates the rate at which the flow of resources will issue. Second, optimal management of that flow will look like unsustainable management of the stock (or "poor management") but is simply the result of staged decision-making.

2 A model of two stage regulation of biological resources

In this section, we use a two stage model of land use conversion to highlight the fundamental causes of Liquorice reduction in Xinjiang, and the corresponding solutions follow. This model of land use conversion is based on Swanson (1994). Land, as an important production input for terrestrial species, however can be also allocated to other productive activities such as agriculture or industry, which compete intensively with the former. Therefore, the property rights over land play a crucial role in biodiversity governance.

As one special herb which can bring income flow, liquorice can be treated as a part of asset portfolio that local communities can choose. What is the best portfolio depends on the social economic characteristics of each society. One would expect in the context of a developing country, large changes in its portfolio to occur(Swanson, 1994), from low-return assets (for example, coal) to high-return ones (machine), in accordance with the changing social economic parameters. Conversions occur between biological assets as well,

by allocating land to different uses.

In order to understand what drives liquorice's decline, we first model how a social planner manages renewable resources. We then model how a local authority allocates its land to different uses, when it responds more to maximum rents and less to optimum social welfare. Then we look at how resource management is able to operate in the context of an independent local authority that has complete discretion over the allocation of land. We show that the management system cannot rectify the problem of independent uncoordinate land use policy. We also demonstrate that the failure to implement the local management system is a given, once the land use allocation has been made.

2.1 Optimal Portfolio Choice

We commence our discussion by considering the situation in which the decision maker is a social planner who internalises all externalities in the pursuit of social welfare optimisation. We assume that the decision maker has control over all Xinjiang resources that support and determine the biological system: land, water, bioligical resource stocks. The decision maker in this instance will consider how to invest and allocate these resources in order to maximise social welfare.

We will consider that the initial lands and resources are heavily invested in the support of the traditional resource (i.e. liquorice in this instance), but it will only be retained if it competes well with other potential uses. Hence, the central planner chooses to allocate land between liquorice and its competing use, for example, agriculture production in order to maximise social welfare. The welfare of the local community, as the most direct beneficiary of biodiversity (as liquorice is an important for soil fixing as well as fodder, besides its medicinal use) is the first element of that function, but also the planner may have an objective function that takes account of social value $S(.)$ (indirect use value, bequest and option value) beyond the simple private market value. $S(.)$ is thus a function of both harvesting rate y and the land allocated for liquorice R. The community chooses its best portfolio to maximize its current value of future return from this asset, under the constraint of natural growth of the resource.

$$\max_{y,R} \int_0^\infty \left[S(y,R) - c(x)y - r\rho_R R\right] e^{-rt} dt \tag{1}$$

$$\text{s.t. } \dot{x} = H(x;R) - y \tag{2}$$

where x is the stock of liquorice; y is harvest rate of liquorice; R is land use for liquorice; ρ_R is the unit rental price of land for liquorice, or representing the opportunity cost of land use if land was allocated for other competing use; r is communities' discount rate; $H(x, R)$ is growth rate of stock of liquorice, increasing in R, and a concave function of resource stock x; $c(x)$ is unit cost of harvesting, which is decreasing with resource stock by dynamic stock effect, i.e. $c'(x) < 0$.

The third term in the objective function reflects the opportunity cost of allocating resource to this natural resource, liquorice in this case. If liquorice is to continue to have the use of land on which it grows, it must be able to afford a competitive return on these. In this case, the competitive return may come from cotton production, or other cash crop which can bring a much higher and quicker return than liquorice.

The optimal solution of harvest rate and land allocation can be reached by solving this dynamic optimization problem, where, λ is the present value of the "shadow price" of a unit of resource stock:

y^*:

$$\lambda = S'_y - c(x) \tag{3}$$

R^*:

$$\frac{S'_R + \lambda H'_R}{\rho_R} = r \tag{4}$$

The optimal land allocation is clear from equation (4), which shows liquorice can receive allocation of land only to the extent that its marginal social value of land allocated to liquorice, together with the discounted future flow of this resource, should be equal to the competitive asset return r. As the current return of cotton is high due to the high economic growth (high r) of China and the high international demand for Chinese manufacturing exportation, together with relatively lower return of liquorice, it is not surprising that more and more land has been converted to cotton and other agricultural production.

The resulting socially optimal resource stock x is determined by:

$$\frac{\dot{\lambda}}{\lambda} + H'_x(x, R) - c'(x)\frac{y}{\lambda} = r \tag{5}$$

If we focus on steady state (where $\dot{\lambda} = 0$ and $\dot{x} = 0$), equation (5) implies that the resource would be maintained at a stock level that equates the return from that asset with the competitive asset's return r, with the return of resource's stock consisting of two parts: the lower unit harvesting cost (or search cost), as well as additional growth. In a high growing economy, low growing resource maintains a low stock.

In sum, the social planner would consider all of the marginal social benefits from retaining the traditional bio-resource, including soil conservation and option values, and it will consider these benefits relative to the alternatives available on the market. The optimal stock of liquorice would be determined by reference to this aggregate value, and the lands and other resources would be managed to retain this stock. This is the socially optimal approach to liquorice conservation: a) allocation of lands and water; and b) management of flow of resource to appropriate maximum social value.

2.2 Local Government and the Land Allocation Decision

A basic problem in China is that the central government makes many decisions regarding environmental objectives, but leaves many of the decisions regarding local resource allocation and implementation to the local authorities. This is a fundamental problem in China, where the central government relies upon the local government to execute central objectives but has few instruments under its control to ensure that these things are done.

With regard to liquorice, there is substantial legislative authority requiring the careful management and permitting of any harvested liquorice. Indeed, the marketing of the herb requires the issuance of several permits: harvesting, processing, exporting. Nevertheless there is little central legal restriction over the allocation of lands to uses other than traditional ones, and the local authorities are given wide discretion in allocating land to different uses. In the context of the growth and development of agriculture in Xinjiang, there has been an impetus encouraging the development of plantation agriculture such as cotton growing.

We will start from the premise that in Xinjiang the decisions about land management are separated from the management of liquorice more generally. That is, local government has the power to allocate contracts in land and thereby dictate land allocations to differing resource systems without any concern for its impact upon liquorice. They are also able to provide water allocations to the same effect. These sorts of conversion decisions either directly through allocations of rights or indirectly by means of subsidies given to other competing uses of land are often seen in developing countries (e.g. subsidies to forest conversion for livestock in Brazil up to the end of the 1980s[2].) Being the biggest exporter of clothing and textiles, China encourages farmers to plant more cotton by providing subsidy, which correspondingly increases the return from allocating land to the alternative assets, in other words, the opportunity cost of using land for liquorice. This

[2] Please refer to Pearce and Moran (1994) for more examples.

in turn provides the incentives for local governmental authorities to allocate contracts in land and rights in water to uses such as cotton.

Thus we revise the model above to demonstrate how land is allocated by reference to differing resources (and without any particular regard to liquorice management). We continue to consider the existing traditional use of land as being grassland and traditional herbs, but consider the situation where there is a subsidy to alternative assets such as plantation agriculture (termed σ). This is an incentive to conversion , or, equivalently, the additional opportunity cost of using land in traditional land uses. In addition to this subsidy to conversion, we will also assume that the local authority focuses more on appropriable benefits in the allocation of resources, rather than the maximisation of social welfare. This is a basic tenet of public choice theory, and it is probably a good approximation of how most land allocation operates in Xinjiang.

The local authority has control over land allocation (R) and wishes to maximise appropriable benefits:

$$\max_{y,R} \int_0^\infty [p(y)y - c(x)y - (r+\sigma)\rho_R R]\, e^{-rt} dt$$
$$\text{s.t. } \dot{x} = H(x;R) - y$$

The optimal allocation of land to any particular bio-resource (here, liquorice) is determined by the following conditions:

$\tilde{y}$

$$\lambda = p'(y)\tilde{y} + p(y) - c \tag{6}$$

$\tilde{R}$:

$$\frac{\lambda H'_{\tilde{R}}}{\rho_{\tilde{R}}} = r + \sigma \tag{7}$$

By comparing (4)and (7), it is obvious that positive subsidy σ will lead to a decrease in traditional land use, and decrease the stock of liquorice through dropping λ:

$\tilde{x}$:

$$\frac{\dot{\lambda}}{\lambda} + H'_x(\tilde{x}, R) - c'(\tilde{x})\frac{y}{\lambda} = r \tag{8}$$

In this section thus far we have shown that the optimal land allocation to the traditional bio-resource (liquorice) would depend upon a) its broader

social benefits (S'); and b) its ability to generate a relative rate of return to land (r). First, this says that the local authorities that govern land use will often fail to take into consideration any benefits than those that are privately appropriable (due to pressures to satisfy local private pressure groups). This is a local governance problem, as the local governmental structure should (in first best world) allow for broad social preferences to be represented in land allocation decisions. Second, this says that the central government's attempt to manage liquorice fails on account of the complete devolution of land use to local authorities, and is in fact exacerbated by the fact of central government subsidies to agricultural development. The land allocation decision regarding traditional bio-resources is being allocated negatively by central government policy.

2.3 Optimal management of liquorice flows given land use

Now an interesting issue arises in regard to the imposition of liquorice flow management by other government authorities, after the land use decision has been made by the local authority. Can the underlying land use decision be altered by means of second stage management? In that case the social planner would attempt to solve the overall problem recognising how the local authority will solve its problem.

In this case, two stage management would provide for the social planner addressing the following problem, given that it recognises how the local authority will allocate land between various land uses given the price of liquorice ($R^l(p)$):

$$\max_{y,R} \int_0^\infty \left[S(y, R^l) - c(x)y - r\rho_R R^l\right] e^{-rt} dt$$
$$\text{s.t. } \dot{x} = H(x; R^l) - y$$

and

$$R^l(p) : \frac{(p'(y)y + p(y) - c)H'_{\tilde{R}}}{\rho_{\tilde{R}}} = r + \sigma \tag{9}$$

where, (9)is given by local government decision, which is combined from (6)and (7). To cause this problem to converge to the unconstrained social planner's problem (above), there are three required interventions: 1) the

central government should not distort the conversion decision by means of subsidising conversion (i.e. $\sigma = 0$); 2) the value of liquorice must be maximised (i.e. $\lambda = p'(y)y + p(y) - c > 0$) ; and 3) the land allocation decision must take into consideration the social benefits of liquorice-based land uses (S(R)) not just the privately appropriable ones (p). It is clear that any management system focused simply on managing the flows of liquorice cannot address all of these divergences. At a minimum, it is necessary to subsidise land use for the public benefits of traditional biodiversity-based land uses.

2.4 Management decision made by separate local government authority

What happens when a central government enunciates a system of carefully orchestrated bio-resource flow management (e.g. harvesting of liquorice) at the same time that there is a local authority implementing massive amounts of land conversion (to, e.g., cotton plantations)? This is another example of the instance in which open access becomes the first-best management regime from the perspective of the implementing authorities. In the case of Xinjiang, the local authorities responsible for implementing the permit systems are the grasslands management offices of Xinjiang, but there is little or no effort actually expended on monitoring and enforcement. This is consistent with other biodiversity management systems, where the underlying forces driving conversion are at odds with the over-lying system of harvesting and management (Swanson 1993).

While it can be argued that harvesting permit system is an effort to "regulate" open access, by substituting land-based property rights with permit-based property rights to make access to resources excludable, it should be noticed that the permit-based property cannot be established without intensive government management investment, without inputting effort in patrolling, enforcing and monitoring the implementation of the permit system. These management services can be treated as another type of input for natural resource management besides land and harvest labour. However, same as land, this management effort is not free, and requires resource that could have been invested in other economic sector.

We can expand the social planner model (1) to show how the local grassland agency makes the choice of liquorice management by choosing the amount of management effort to expend on managing access:

$$\max_{M,y} \int_0^\infty [S(y,M) - r\rho_M M]\, e^{-rt} dt$$
$$\text{s.t. } \dot{x} = H(x, R^l) - y$$

where:

$$R^l(p) : \frac{(p'(y)y + p(y) - c)H'_{\tilde{R}}}{\rho_{\tilde{R}}} = r + \sigma \tag{10}$$

Here M is the management effort expending on monitoring access to and harvesting of the natural resource, with ρ_M as the "price" or opportunity cost of this effort. $S(y, M)$ is the flow of social benefits from liquorice, and concave in M.

The problem is once again that the problem is being predetermined by the land use decision. Here one local authority is making the land allocation decision (R) and another is making the monitoring and implementation decision (M). Given that the local authority decides to allocate more land to other uses, there will be an additional flow of harvested liquorice available, and there is no return to be had from managing the flows. In effect, the solution to the land allocation problem pre-determines the solution to the monitoring/management problem since reduced stocks are determined by the reduced land allocation.

What is the optimal allocation of management resources in this situation, and the "optimal" management institution. The optimal investment in management institutions is given by M:

$$\frac{\lambda S'_M}{\rho_M} = r \tag{11}$$

The optimal level chosen by the government will invest in institution building at the level in which the perceived benefit that flows from this investment equals the economy competitive return. Management level M is decreasing with growth rate r, management cost ρ_M, and increasing in resource shadow value λ. Therefore it is rational to have low management input under high growing economy, and with a large area of grassland to look after(ie., monitoring is costly). If the management level is low, the "regulated" regime will be close to open access. That is to say, the open access is the result of the choice made by the government. In this instance (where the land conversion problem dictates that stocks of the biological resource

must fall) the return to management is at or near zero (S'(M)=0). There is no reason to expend management resources on a management system in which reduced stocks are pre-determined by the local land use authority.

In this sense, the decline of the biological resource is a function of the separation of functions between the various agencies in Xinjiang, and the manner in which a decision by a single agency predetermines the problem for the others. Here the land use decision is the fundamental one, made by the local agency to maximise privately appropriable values. This then determines that the stock of land allocated to liquorice is declining from its traditional level. This conversion of lands also indicates that reduced stocks of liquorice are a given (since there is some linear relationship between land and plant). The implied reduction of stocks results in necessarily increased flows. The disinvestment programme implicit in the land use conversion means that the optimal management level is low. There is little reason to enforce a harvest management system against the background of an implicit disinvestment programme. This means that there is little incentive in setting up clearly defined property rights. Second, although permit-based rights are put into place to substitute land-based rights, the government authority's financial and manpower input is too low to ensure the proper enforcement of the new system. Therefore, it is not surprising to have *de facto* open access as the resource is driven into decline.

3 Discussion of the model

The general model outlined above shows that the uncoordinated regulation and the preemption of the harvest permit system by the land use system are the fundamental problems in Xinjiang biodiversity governance. In order to understand these points more concretely, we are providing more empirical discussions of the property rights of land in China and the undergoing land conversion process in this section.

As Peter Ho (2005, pp.174) recognizes, one of the pressing issues that await a political solution is the unclear tenure system for grasslands: the heritage of a collectivist past. Soon after the foundation of People's Republic of China, customary rights structures for grassland were delegitimized and supplanted by the institutional system of the people's communes. Although ownership rights were formally vested in the production teams (an administrative unit below the commune), the pastures were open to all. This practice of uncontrolled grazing persisted after the demise of the communes in the 1980s, as free-riding becomes the most natural grazing strategy. Although the grassland use contracts have usually been issued to individual households

and contain the area of grassland supposedly contracted to them, neither contracts nor pastoralists have demarcated individual household boundaries and small-group common property arrangements persist (Tony Banks, 1999). In a survey conducted by Ho (2005) in NingXia Hui Muslin Autonomous Region[3], 86% of the respondents feel that "because the rangeland is not theirs but state-owned, it is common property and thus open to everyone. Apart from the area that is fenced in, it is very difficult to exclude outsiders from digging for liquorice root in village pastures." The majority of farmers (57 per cent) also think that the boundaries of the village pastures may not be very clear to people from neighbouring villages.

As a result of ill-defined property rights, Xinjiang has undergone extensive land use conversion since the 1950s, mainly from desert steppe into cultivated land. While since 1990s, when China's economy kept growing and labour became more mobile, Xinjiang has furthermore attracted farmers from inner provinces seeking more land, as it accounts for 1/6 of China's land area while with low population density. Although reclamation has been prohibitively forbidden (Article 30 (2004), Ministry of Agriculture), local researchers and regulators claim reclamation or property development are still taking place. Various levels of the Grassland Monitoring and Supervision Centre have confirmed this claim. The table (1) shows the scale of land transformation during the last decade.

In the process of reclaiming the land, wild liquorice is picked and sold to harvesters. Liquorice harvested through reclamation, however, is not subject to the harvest quota required by the grassland management office. This priority of land conversion over liquorice protection restricts the effect of biodiversity management to a great extent.

This problem is exacerbated by the low management input from central government. Without financial support, manpower and transportation facilities available to the county level GMSS are not sufficient to ensure the effectiveness of the permit system. For example, only two of the nineteen employees at the Kurla GMSS actually monitor and investigate the grasslands in Kurla county, which covers 346,700 hectares. They share one car, and it is physically impossible for them to monitor even a fraction of the grassland in Kurla. The situation is similar in other counties such as Akusu and Hetian, which are two other major liquorice grasslands areas.

Given the land conversion decision made by the local government authority, liquorice management became rather arbitrary and has low return.

[3]NingXia Hui Autonomous Region is another Muslin dominated region, located in Northwest China

Table 1: Increased Area of Arable Land in Xinjiang, 1997-2005

Year	Increased arable land area (hectare)	Among which, by land development	Percent
1997	67,246	58,959	87.68
1998	54,852	49,894	90.96
1999	79,203	71,593	90.39
2000	55,817	46,022	82.45
2001	13,706	11,813	86.19
2002	46,267	30,378	65.66
2003	39,424	35,505	90.06
2004	22,151	16,307	73.62
2005	60,110	18,176	30.24
Total	438,780	338,650	77.18

Data source: Luo Qiaoshun 2008

Low management effort resembles open access. The reported low profits of harvest organizers[4] are consistent with the view that there are no significant barriers to entry. The table (2) lists the number of harvesting applicants every year since 2004, and the quotas approved. There is a quite large distribution of quotas over applicants, with most being below 100 tons, while some processors, who sometimes also apply for harvesting license, can get an amount as high as 3000 tons. From this table, we can see that entry to and exit from this business is very flexible. This is another problem. If the permit is only valid for a single season, then there is no reason for the legal harvester to leave roots behind. The time-limitation on the permit removes the incentive to invest in the future of the root supply, and to focus instead only on current exploitation. An annual system operated in this manner gives harvesters no incentive to internalize dynamic externalities of their harvesting behaviour.

In sum, land conversion invalidates bio-resource management. When the traditional resource is difficult to compete with other economic plants for land use, traditional resource stock decreases as the land on which it is based is converted away, which further discourages the management of resource flow, especially when the resource price drops with the dumped liquorice from the converted land.

[4] Harvesters are reported to earn very little in this industry, with earning equivalent to the lowest wage rate at the local level.

Table 2: Number of harvest applicants each year

Year	Number of harvest applicants	Total approved quota (tons)	Minimum approved quota (tons)	Maximum approved quota (tons)	Medium approved quota (tons)
2008	49	6615	20	3000	50
2007	71	4595	10	1000	35
2006	34	3625	15	600	55
2005	47	6080	10	500	90
2004	41	5255	20	300	100

Source: constructed from the medicinal plants permit licenses for each year since 2004.

Besides slow growth of the bio-resource, it is also possible that traditional use of land encompass many other values that are not easily or officially registered. First, the economic value of biodiversity is not fully reflected in markets due to market failure. There is value to maintaining traditional land uses that conserve soil and maintain options for the future. Second, government intervention also plays an important role in this land conversion process. For example, agricultural policies often encourage conversions by offering financial incentives for planting cotton and instilling irrigation systems.

Whether it is possible to find ways to capture or realize the economic value of liquorice is essential for biodiversity conservation (Pearce and Moran, 1994). A use value is a value arising from the actual use made of a given resource. Use values are further divided into 1) direct use value, which refers to actual uses such as fishing, 2) indirect value, which refers to the benefits deriving from ecosystem functions such as a forest's function in protecting the watershed, and 3) option values, which is the value of an individual's willingness to pay to safeguard an asset for future use. Non-use values are slightly more abstract and difficult to measure, but are usually divided between a bequest value and an existence or 'passive' use value. The former measures the benefit accruing to any individual from the knowledge that others might benefit from a resource in future. The latter are unrelated to current use or option values, deriving simply from the existence of any particular asset.

Table (3) displays these values and the corresponding implication for liquorice. Liquorice has extensive direct use value, most of which has been captured by processing industries and consumers, rather than by farmers and their land. Its indirect use value and other values are always neglected by government or land developers. Policy movements towards internalizing these values, from left to right, will decrease land conversion and benefit biodiversity conservation.

In sum, the existing and traditional uses of land are always in a competition with other potential uses of that same land. Land conversion is the single most prominent source of biodiversity decline globally. Liquorice root is also in jeopardy on account of other potentially profitable uses of the lands on which it has traditionally been situated. There are two basic failures that contribute to this problem. The first is the market failure that derives from the inability of societies everywhere to capture the broader values of biodiversity and to channel them to land owners. The lands on which liquorice resides benefit from the prevention of soil erosion, and the protection of the environment in general. These values need to be internalised to the land owners if they are to aid the conservation of the lands themselves. Just as

Table 3: Categories of economic values attributed to environmental assets and liquorice as example

	Use Values			Non-use Values	
	Direct use value	Indirect use value	Option values	Bequest values	Existence values
Definition	Outputs directly consumable	Functional benefits	Future direct and indirect values	Use and non-use value of environmental legacy	Value from knowledge of continued existence
Values of liquorice	Liquorice roots used in medicine, or as food addictive	Sand fixing; halt desertification	Other active ingredients or functions yet to be found from liquorice	Habitats, prevention of irreversible change to desert	Liquorice species, Wild liquorice gene, Ecosystem
The extent to which the value of liquorice has been captured	Most part has been captured by processors/wholesalers, but not farmers, land investors	little	No	No	No

importantly, governments need to recognise that traditional land uses can be competitive with highly cultivated ones, and need not encourage conversions beyond their optimal level.

4 Conclusion

We have used a model of land use conversion to describe the fundamental causes of over-exploitation of liquorice in Xinjiang, i.e. unclearly defined property rights and government intervention failure. In this model, open-access is not an ex-ante assumption, rather it is the outcome of policy choice. The fundamental problem is that the local authority in control of land use is making land allocations which pre-determine the choices of all others involved in the system. The fundamental decision to convert land to other land uses (for private appropriation of rents) means that stocks of the bio-

logical resource must decline in tandem with the stocks of such lands, and it further means that there is little reason to allocate scarce resources to the management of a system of disinvestment. When few resources are invested in management of the process, poor management systems result. In the case of Xinjiang, this means that the harvest permit systems remain largely unimplemented as a complement to the system of disinvestment and conversion that is occurring there.

Under this de facto open access regime, local communities are not eligible to protect their land and properly manage their natural resources because of the vague and nontransparent system of property rights. In the general development of the economy, the local decision makers are not included in the local objectives any longer. "Whose land is it?", as asked by Peter Ho(2005), determines how the land is managed in the end, as well as the resource attached to it. In other words, displacement of local peoples from decision making is the main cause of biodiversity decline in Xinjiang, as much as in many other parts of the developing world.

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