16. Beyond Trees: Restoration lessons from China's Loess Plateau

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Introduction

China has the highest afforestation rate in the world, resulting in an increase in forest cover of 9 per cent over the past 30 years (Wellesley 2014). This is not for reasons of altruism. Since 2000, China has emerged as the main processing hub for the world's forest sector. China is now the world's largest importer and consumer of wood-based products (Hoare 2015). Yet historical forest loss has made China one of the most forest-deficient countries in the world, with a national forest cover of 22 per cent, compared with the global average of 31 per cent (FAO 2012). Tree loss, moreover, is just the tip of the iceberg. China is also one of the most water-stressed countries on the planet, having 21 per cent of the world's population, but only 6 per cent of its freshwater (Wong 2013). Sustainability of both water resources and land affects the population and the economy.

As a country with a population of more than 1.3 billion people and given the above constraints, China is among those countries facing the highest adverse risk levels around climate change (Department of Climate Change 2015). Historical deforestation, land conversion, overgrazing and mining have left landscapes particularly vulnerable. Devastating floods, desertification and sandstorms have forced China to take action to restore its land, particularly when considering increased threats from climate change and the need for food and natural resource security (World Bank 2006).

To combat these compounding issues, China will need increased crop productivity, resource use efficiency and environmental protection (Fan et al. 2012). To facilitate disaster preparedness, the Chinese Government has made significant financial investments to restore degraded areas. Restoration refers to the long-term process of regaining ecological functionality and enhancing human well-being across deforested or degraded landscapes. Restoration is a key tool to mitigate disasters arising from degradation and to protect natural resources (Buckingham et al. 2016).

Policy is therefore essential to protect land and resources facing adverse impacts from climate change, development and population pressure. At the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP21) in Paris in December 2015, countries across the globe committed to create a new landmark international climate agreement: to keep global temperature increase below 2°C (3.6°F) and to pursue efforts to limit it to 1.5°C (BBC 2015). Countries publicly outlined what post-2020 climate actions they intend to take under a new international agreement. These are known as their 'intended nationally determined contributions' (INDCs).

Of course, forests have a key role to play in carbon sequestration. China's INDCs related to forestry aspire to increase forest carbon stocks by 4.5 billion cubic metres. This implies an increase in forest cover of 50–100 million hectares (124–247 million acres) of forest, or about two to four times the size of the United Kingdom. This amount of forest would create a roughly 1 gigatonne carbon sink, equivalent to stopping tropical deforestation for almost a full year or taking 770 million cars off the road. This is on top of significant progress already made: China increased its tree cover by 49 million ha (121 million acres) between 1990 and 2010 (Frazen et al. 2015).

China's INDCs plan promotes afforestation, voluntary tree planting, protection of natural forests and restoration of forest and grassland from farmland. Controls intend to be implemented to mitigate sandification for areas in the vicinity of Beijing and Tianjin and desertification, to reduce soil erosion and enhance water reserves (Department of Climate Change 2015). Prior to the INDCs, nationally, China invested about US$100 billion in six forestry programs, which covered more than 97 per cent of China's counties and targeted 76 million ha of land for afforestation (Cao et al. 2010a). In 1999, the Chinese Government launched 'Grain for Green' (Tang et al. 2013), one of the world's largest conservation programs. Grain for Green consisted of projects and practices designed to curb soil erosion, increase the amount and variety of natural vegetation in the landscape and introduce more sustainable land management practices. The program included a payment for ecosystem services that directly engaged millions of rural households in project implementation (Lu et al. 2012).

Most recently, the Thirteenth Five-Year Plan (FYP) put forward in 2016 aims to enhance and complete a series of national geographic databases for natural resources, including one for forests. Key data include forecasts—for example, that the national forest coverage rate is expected to reach 23.04 per cent and forest carbon storage volume will reach 9.5 billion tonnes by 2020. In addition, the plan identifies four key areas of focus in forestry: 1) policy and institutional reform; 2) forest resource conservation; 3) forest quality and efficiency improvement (for restoration); and 4) forest management, protection and innovation. First, state-owned forest areas will be reformed to promote government, public institutions, enterprises and management in a streamlined manner with more efficient state-owned forest management agencies. Second, natural forests, forest resources and wetlands will be conserved and protected and a rare and endangered species national park established. Third, the pace of afforestation will be accelerated with the aim to strengthen forest management, improve the quality of forest resources and national timber reserves as well as develop the forest economy, forest tourism and nurseries for restoration. Last, the government aims to strengthen forest protection through prevention and control of forest fires and pests using scientific and technological innovation in forestry. China's forestry database platform was launched in February 2016 (Xinhua Net 2015).

Part of the solution to maintaining forest stocks, increasing forest quality and allowing for restoration involves logging bans. Part of the Central Government's Thirteenth FYP includes a ban on commercial logging of natural forests in state-owned plantations by the end of 2016.[1] The first such pilot was a ban on all commercial logging of natural forests in key forest zones in north-eastern China's Heilongjiang province in April 2014 (Hoare 2015). Heilongjiang has historically produced over 30 per cent of China's domestic log supply (Sun et al. 2016). The forestry component of the Thirteenth FYP and this new logging ban are essential to maintain the country's demand for timber. Some 49.94 million cu m of natural forest are presently logged each year. Since more than half of China's timber demand is met by imports, it is also important that controls be put in place to ensure the legality of timber resources being sourced from abroad (Jie 2015). At present, it is estimated that exports destined for China make up half of all the global trade in illegal wood-based products (Hoare 2015). There is speculation that the vision for a greener China may end up exporting environmental damage to other, more vulnerable countries through sourcing timber from beyond China (Thiel and Sun 2016).

It is too early to speculate on the outcomes of new legislation and how the international INDCs will affect national policies, both of which have significant implications for forest reserves. However, lessons have been learnt from existing land degradation across China. Some of the most acute crises triggering strengthening resolve to restore degraded land relate to sandstorms that hit downwind urban areas. A particularly highly publicised case, soil erosion in the Loess Plateau, contributed to massive sandstorms that periodically choked Beijing during the 1980s and 1990s, including the infamous 'Black Wind' of

1 The ban will be completed nationwide by 2017. This is an extension of a program that was started in 1998, which aimed to allow forests to recover from decades of overlogging and to help restore forest ecosystems and their resilience. The halt of commercial logging in state-owned natural forests in Heilongjiang province started on 1 April 2014. The extension of the ban in April 2015 covered all natural forests across north-eastern China and Inner Mongolia and the government plans for further expansions to all other state-owned natural forests, including those in the 14 provinces not currently covered by the National Forest Protection Program (Sun et al. 2016).

1993 (Qian and Quan 2002). It is no surprise that the first World Bank Loess Plateau project started a year later. Soil erosion was so severe that the plateau contributed more than 90 per cent of the total sediment entering the Yellow River (Chen et al. 2007). Furthermore, a large amount of once cultivated land had to be abandoned in the Loess Plateau due to soil degradation, resulting in economic losses of approximately US$1.28 billion over recent decades and an unprecedented threat to food security (Chen et al. 2007).

Loess Plateau: A case study

The Loess Plateau in north-central China is a large, hilly, semi-arid region roughly the size of Afghanistan. Thousands of years of farming, which intensified during the Cultural Revolution, left the former grasslands degraded and eroded. Food production was down, waterways filled with silt and air in faraway cities suffered from sandstorms born on the Loess Plateau. The fact that the local population had reached some 50 million people made the problems worse. Something had to be done.

In 1994 a restoration effort began. Two Loess Plateau watershed rehabilitation projects were implemented in 48 counties across Shanxi, Shaanxi and Gansu provinces and the autonomous region of Inner Mongolia (Liu and Hiller 2016). One the one hand, some observers may not consider the restoration of these 1,100 watersheds within the Loess Plateau a strict case of 'forest landscape restoration', due to the use of extensive afforestation (introduction of trees on lands not historically forested). On the other hand, the restoration effort—or bid to restore ecosystem functionality—did exhibit a number of the features and key success factors of forest landscape restoration (Hanson et al. 2015). Importantly, these generate insights for other forest and landscape restoration initiatives and lessons for future projects (Hanson et al. 2015).

Given the significance of the Loess Plateau and also of the restoration effort, the latter was chosen as one of 16 forest landscape restoration case studies worldwide for a large forestry review project by the World Resources Institute (WRI) (Hanson et al. 2015).

Via literature review and expert interviews, each of the 16 case studies was analysed in search of common features of restoration success and failure. Three common themes for successful restoration were identified (Hanson et al. 2015):

- *A clear motivation*. Decision-makers, landowners and/or citizens were inspired or motivated to restore forests and trees in landscapes.
- *Enabling conditions in place*. A sufficient number of ecological, market, policy, social and/or institutional conditions were in place to create a favourable context for forest landscape restoration.

- *Capacity and resources for sustained implementation*. Capacity and resources existed and were mobilised to implement forest landscape restoration on a sustained basis on the ground.

Within each of the three themes, relevant historical examples point to a number of factors that, when present—either already naturally or because people have taken steps to create them—increase the likelihood that restoration will be successful. The key success factors are summarised in Table 16.1, in the 'Restoration Diagnostic'.

Table 16.1 Key success factors for forest landscape restoration

Theme	Feature	Key success factor
Motivate	Benefits	• Restoration generates economic benefits
		• Restoration generates social benefits
		• Restoration generates environmental benefits
	Awareness	• Benefits of restoration are publicly communicated
		• Opportunities for restoration are identified
	Crisis events	• Crisis events are leveraged
	Legal requirements	• Law requiring restoration exists
		• Law requiring restoration is broadly understood and enforced
Enable	Ecological conditions	• Soil, water, climate, and fire conditions are suitable for restoration
		• Plants and animals that can impede restoration are absent
		• Native seeds, seedlings, or source populations are readily available
	Market conditions	• Competing demands (e.g., food, fuel) for degraded forestlands are declining
		• Value chains for products from restored area exists
	Policy conditions	• Land and natural resource tenure are secure
		• Policies affecting restoration are aligned and streamlined
		• Restrictions on clearing remaining natural forests exist
		• Forest clearing restrictions are enforced
	Social conditions	• Local people are empowered to make decisions about restoration
		• Local people are able to benefit from restoration
	Institutional conditions	• Roles and responsibilities for restoration are clearly defined
		• Effective institutional coordination is in place
Implement	Leadership	• National and/or local restoration champions exist
		• Sustained political commitment exists
	Knowledge	• Restoration "know how" relevant to candidate landscapes exists
		• Restoration "know how" transferred via peers or extension services
	Technical design	• Restoration design is technically grounded and climate resilient
		• Restoration limits "leakage"
	Finance and incentives	• Positive incentives and funds for restoration outweigh negative incentives
		• Incentives and funds are readily accessible
	Feedback	• Effective performance monitoring and evaluation system is in place
		• Early wins are communicated

Source: Hanson et al. 2015.

The diagnostic was developed as a structured method for identifying which key success factors for restoration are already in place, which are partially in place and which are missing within a country or landscape that has restoration opportunities. It is a qualitative tool and is intended as a way to help decision-makers and restoration supporters rapidly focus their efforts on the most important factors to get in place—before large amounts of human, financial or political capital are invested. When applied periodically every few years once a restoration effort is under way, the diagnostic can help implementers adjust and refine their policies and practices as a means of adaptive management.

A few caveats are important to note. First, no case example exhibited every single key success factor. Thus, it appears that a landscape need not have *every* key success factor in place for restoration to succeed. Second, no single factor appears to be necessary or sufficient for restoration success; a combination is needed. However, some key success factors appear to be particularly important for restoration via natural regeneration (for example, ecological and market conditions), while others are particularly important for active restoration (for example, clear tenure). Third, some of the key success factors are interrelated and can have effects on other factors. For instance, performance monitoring is a key success factor for implementation that, in turn, can further motivate restoration when monitoring is used to widely communicate emerging successes and benefits of restoration (Hanson et al. 2015).

Recognising key success factors

Motivating factors

The Chinese Government became motivated to pursue restoration of the Loess Plateau due to several factors. As with many examples of large-scale restoration, including cases in South Korea and Ethiopia (see Hanson et al. 2015), crisis was the principal trigger to resolve to restore the Loess Plateau, with sandstorms in the late twentieth century hitting downwind urban areas. Decision-makers recognised that landscape restoration would provide a number of economic, social and environmental benefits. Economically, it would improve food security and diversify income generation opportunities, particularly for poor rural communities (Tsunekawa et al. 2014). In the Loess Plateau, funding from the World Bank and the Chinese Government helped restore 4 million ha of land, reportedly more than doubling the incomes of local farmers, reducing erosion by 100 million tonnes of sediment annually, reducing flood risk and dramatically increasing grain production. Socially, it aimed to strengthen household stability and reduce migration to cities. Environmentally, restoration aimed to improve soil health, reduce erosion, ensure cleaner water and sequester carbon (Lu et al. 2012).

Enabling conditions

Several enabling conditions were in place to facilitate restoration in the Loess Plateau—namely, ecological, policy and market conditions. First, ecological conditions: via the Grain for Green program, factors prohibiting the recovery of natural vegetation were removed. In particular, prohibiting grazing in areas designated for restoration resulted in a 99 per cent increase in vegetation cover in those areas (Cao et al. 2011).

Second, policy conditions: clearing restrictions and land rights played important roles. After 1999, for instance, the government banned the cutting of trees and crop-growing on slopes and withdrew permission for unrestricted grazing in the region. The imposed grazing ban became a cornerstone of the strategy to reverse soil degradation in the Loess Plateau area and to re-establish natural vegetation (Hiller and Guthrie 2011). Just as importantly, the bans were enforced. Combined with replanting of vegetation, these bans allowed the perennial vegetation cover to increase from 17 per cent of the region to 34 per cent by the mid-2000s (World Bank 2007b). In addition, the government granted local people the opportunity to take out low-cost land leases to restore fields, followed by the opportunity to acquire land rights such that commodities or payments for ecosystem services derived from a tract of land belonged to them (World Bank 2007a). Further, the Rural Land Contracting Law of 2003 provided security for land users. While farmland use contracts are valid for 30 years, those for grassland extend to 30–50 years and for forest land to 30–70 years (Zhao et al. 2014).

Finally, market conditions: there were value chains for products from restored areas. Originally, the effort to motivate cooperation from local farmers focused on fruit trees and vegetables, with a small amount of payments for ecosystem services. However, what farmers asked for most during the first phase of the World Bank effort was help with new livestock enterprises. Much of the second phase of the World Bank project became a livestock project, with successful introduction of Kashmiri sheep (confined) for wool, dairy cattle (confined) and lots of planting in difficult areas for biomass harvest. Both of these livestock activities were new in the area, made possible by the new biomass being generated through restoration. The success of the new labour-intensive, high-value livestock enterprises based on better biomass management are what will likely determine the future of the Loess Plateau. Loess provides an important example of why forest and agricultural restoration are highly synergistic (C. Delgado, personal communication, 3 September 2015).

Implementation factors

During the restoration period, capacity and resources for implementation came into place that facilitated restoration, including leadership, knowledge and technical design and funds and incentives. Regarding leadership, the Chinese Government and the World Bank demonstrated sustained commitment to Loess Plateau restoration, particularly through the Grain for Green policy from the late 1990s (Hiller and Guthrie 2011).

Regarding knowledge and technical design, in partnership with the World Bank, the Chinese Government created a restoration plan that included both technical design and capacity development. The technical design component included activities focusing on terracing, afforestation, orchards, grasslands, sediment control dams, irrigation, grazing and gully control. The capacity development component included activities focusing on training, research and technology transfer (World Bank 2003). Integrated watershed management practices created water-harvesting structures and ensured continuous vegetative cover through large-scale reafforestation, grasslands regeneration and agroforestry methods (EEMP 2013).

Regarding funds and incentives, the Loess Plateau restoration project had significant project financing: a budget of approximately US$500 million over the period 1994–2005. Finance included direct Chinese Government expenditures and World Bank loans. This finance fuelled subsidies that made converting degraded farmland into trees and other vegetation economically viable for farmers. Subsidies included US$122/ha for seeds and seedlings and a payment for ecosystem services of US$49/ha per year lasting for two to eight years (World Bank 2006).

Challenges to sustainability

The positive impacts of the Loess Plateau restoration project have received a lot of attention. Many ecological and social benefits have been recognised (World Bank 2006; Ferwerda 2012; Tsunekawa et al. 2014). Policy change and enforcement were essential to this success, especially in stopping grazing and controlling land use change.

According to the World Bank, in some places in the Loess Plateau, local farmers saw their incomes double, erosion was reduced by 100 million tonnes of sediment annually, there was a reduction in flood risk and grain production dramatically increased. However, these results also brought costs. The speed of China's effort was possible only by using single species or minimally diverse plantings, and local communities were often unable to enjoy the benefits of restored forests. While in some areas restoration has protected land from desertification and brought better rural livelihoods, in others, trees have grown slowly and some are already dying. Chinese experts readily admit trees were sometimes planted in arid regions better suited to grass. This has led to a growing desire to 'green China naturally' (Cao et al. 2011).

The Loess Plateau's performance against several key success factors highlights what may become challenges to the long-term sustainability of the region's restoration, including awareness, finance and incentives, ecological conditions and technical design.

In terms of awareness, the benefits of restoration and soil conservation currently may not be sufficiently understood by all relevant local populations and local officials (Chen et al. 2007; Lu et al. 2012). This lack of awareness may be due—at least in part—to the top-down nature of the project's design and decision-making. More local participation and engagement could address this information asymmetry. Most farmers—both inside and outside project areas—participated in the project activities, but sometimes they were mandated to do so by the government. Thus, while participation rates were high, the local sense of ownership of project processes and plans could have been higher (Hiller 2012).

Regarding finance and incentives, a survey of farmers in the region indicated that 56 per cent would recultivate sloping land once the subsidies cease in 2018 (Chen et al. 2007; Jiao et al. 2012). Furthermore, some researchers have argued that the eight-year payment for ecosystem services is too short: the subsidies stop before the land generates a high enough yield and before robust markets for products from the restored landscape have developed. For example, apricot trees take time to bear enough fruit to provide an economic return (Chen et al. 2007). Given that the cities downstream (for example, Beijing) are large and have an interest in reducing sandstorms, increased water quality and reduced flooding of the Yellow River, perhaps payment from urban dwellers to rural dwellers is warranted (Hiller 2012). Furthermore, Cao et al. (2009) noted that transferring state property to private ownership alone is not enough of an incentive for residents to protect and restore the land (Cao et al. 2010c). Because most of the program's plots are in impoverished regions of China, the ban on logging and open grazing has led to severe shrinkage in the parts of the economy that were based on forest resources and open livestock grazing. In some regions, inadequate compensation or alternative livelihoods were available (Cao et al. 2010a).

Besides donor funding, the private sector has an important stake in restoration. Popularising the danger to the food industry (of toxins, additives and bioaccumulation), coupled with the environmental needs for restoration, can be leveraged to motivate industry to engage in restoration efforts. For example, outside the Loess Plateau in southern China, Danone, a multinational food products corporation, is piloting projects with 'dynamic farming' techniques from Australia. Danone is piloting financial models that allow the farmers to see the impact of restoration on their business: one that allows them to switch to native Chinese fir instead of non-native, rapid-growing Eucalyptus, one that provides competitive prices in the high-end honey market and one that proves that mandarins can be farmed without high chemical input (Buckingham 2015). Working at small scale will not solve the problem of degradation, however, engaging the private sector to facilitate restoration of landscapes will help identify restoration as a necessity.

Regarding ecological conditions, in some parts of the plateau, non-native tree species were planted in an area more suited to grasses. Furthermore, an adequate supply of high-quality tree and shrub seedlings was lacking due to inadequate incentives for timely delivery. For example, performance targets were not aligned with in-the-field success, as nursery objectives were to transplant all seedlings regardless of quality. As a result, many of the trees planted were unable to survive drought years and about one-third had to be replaced. The situation marginally improved towards the end of the project due to the agricultural reforms of 2002, which established some private nurseries. Nonetheless, farmers and government officials maintain that the supply of high-quality seedlings is a challenge (World Bank 2007a).

Some technical features of the Loess Plateau project have come under scrutiny. One area is afforestation, which has been accepted as an important strategy for preventing soil erosion on the plateau. Increasingly, however, Chinese scientists are debating the long-term sustainability of afforestation in such a semi-arid environment (Jiao et al. 2012). The total survival rate of trees in the Loess Plateau has been low in some areas. For instance, 400,000 Chinese pine trees were planted in northern Shaanxi, but only 25 per cent survived (Chen et al. 2007). Managers often prefer short-lived species that offer attractive short-term gains, but landscape regeneration involving the species mix needed for sustainability is typically a long-term process (Cao et al. 2010b, 2011).

Another area of scrutiny is climate resilience. Some researchers have raised questions about the resilience of the project's technical design in light of the regional climate having a warming and drying trend. Within the context of climate change, large-scale afforestation on Loess soils could increase the severity of water shortages (Cao et al. 2007) owing to increased evapotranspiration from trees. In addition, if trees do not grow adequately, they will be unable to control runoff and soil erosion (Chen et al. 2007). Because of poor species/site pairing, excessive tree planting (Cao et al. 2007) and poor management, in some areas tree plantations have grown well initially but later die due to water shortages (Chen et al. 2007). Vegetation restoration strategies, therefore, need to be tailored to the water availability and other ecological conditions of the region (Chen et al. 2010; Cao et al. 2011). For instance, restoration designs could rely less on pine plantations, favour tree species with more drought resistance and utilise shrubs and alternative vegetation better adapted to the ecological conditions (Cao et al. 2007; Chen et al. 2007; Jiao et al. 2012).

It is easy to blame restoration mistakes on poor science, but that underplays the importance of culture. The open, semi-arid landscape of the Loess Plateau is home to the Hui ethnic people and is peppered with mosques. This landscape is very different from the cultural ideal of the Han ethnic people who make up 92 per cent of China's population and dominate its political and cultural life.

China has worked hard to create a sense of national unity, making Mandarin (the language of the Han people) the country's common language, in 1912. In 1949, Chairman Mao Zedong decreed that all of China would operate on Beijing time, even though the country spans five time zones. Nature, however, will not be bound by our sense of order. It is important to consider what land managers could learn from the Hui people's historical relationship with their landscape. The trees planted on the Loess Plateau were biological settlers, foreigners to the arid landscape. The settler trees also represent the migration of a cultural perspective. While the introduction of non-native plants attracts scientific and public attention, the cultural perspective is often overlooked. Cultural bias can be difficult to perceive; as the Chinese poem states, it is difficult to see the situation when you are deeply involved: you can't see the forest for the trees.

The restoration of the Loess Plateau is unmatched in scale, yet the allure of non-native species to engineer a desired outcome in the landscape is common globally. We need to understand the biophysical and cultural factors to build on the indigenous ecological and cultural memory of the landscape. With changing climate and increasing populations, we need to restore landscapes to ensure the resilience of ecosystem services in the twenty-first century, recognising that cultural diversity is as important as biodiversity in restoration decisions (Buckingham et al. 2014).

Looking forward: Restoration strategy for rehabilitating severely degraded areas

The Loess Plateau has gained much attention for overgrazing, farming and tree planting. Yet, China's land use challenges transcend issues of land utilisation towards arguably more destructive degradation: mining. To successfully restore land, strategies need to go beyond narrow tree and afforestation programs to the need to implement ecologically sustainable land cover to protect soil quality. A sobering report by the Ministry of Environmental Protection (MEP) highlighted the extent of soil degradation, which renders one-fifth of China's soil fallow—a consequence of exposure to heavy metal contaminants (MEP 2014; Patel 2014). This is largely due to mining activities.

There are more than 9,000 large and medium-sized mines and 26,000 small mines in China (Li et al. 2014). Mineral resources play a key role in Chinese economic development. There are 171 varieties of mineral resource in China, accounting for 12 per cent of total global mineral resources (Hu et al. 2010). Soils surrounding mining areas are seriously polluted by heavy metals emitted from mining activities. This kind of pollution not only degrades the quality of the atmosphere, water bodies and food crops, but also threatens the health and well-being of animals and humans by way of the food chain, particularly through bioaccumulation. Soil pollution by heavy metals poses high carcinogenic and non-carcinogenic risks to the public, especially to those living in the most severely polluted regions (Hu et al. 2010).

The Loess Plateau area is home to a significant amount of mining activities, which further threaten the landscape. Open-cast coalmines are primarily located in the environmentally vulnerable regions of north-western China, such as Shanxi province, Inner Mongolia, Gansu, Ningxia and Shaanxi province (Zhang et al. 2015). Large areas of degraded mining land remain barren, preventing agricultural, social and economically sustainable development in affected areas. As land is in short supply in China—exacerbated by the rapidly expanding population—it is now policy to restore or reclaim land degraded by mining (Miao and Marrs 2000). Policy mandates that the ecological environment of 45 per cent of historical abandoned mines must be rehabilitated, and the environment of 30 per cent of polluted mining areas should be restored. New mines are required to restore 100 per cent of their land (Hu et al. 2010).

Extensive grasslands like those within the Loess Plateau are being converted globally. Grasslands are being lost to agriculture, tree plantations, mining and urban development and degraded by invasive species, poorly managed domestic livestock, altered fire regimes, elevated atmospheric carbon dioxide and nitrogen deposition (Veldman et al. 2015a). Tree planting, fire suppression and exclusion of native or domestic grazers are suitable restoration strategies in deforested landscapes. However, interventions such as these can have negative consequences when applied to biomes such as grasslands, savannas and open canopy woodlands. There needs to be a clear distinction between 'reafforestation' (planting trees on deforested land) and 'afforestation' (converting historically non-forested lands to forests or tree plantations) to ensure sustainable restoration strategies (Veldman et al. 2015b).

To facilitate sustainable landscape restoration, lessons from the Loess Plateau case study should be learned and mistakes not repeated. A thorough assessment needs to be conducted to understand the landscape opportunities and challenges for China at specific landscape scales. The restoration diagnostic can be utilised as one part of a toolkit developed by the International Union for Conservation of Nature (IUCN) and the WRI, known as the Restoration Opportunities Assessment Methodology (ROAM). Since mining restoration and rehabilitation are now mandated, ROAM can assist in facilitating the development of a restoration strategy. The methodology would help avoid some of the pitfalls that led to unsustainable restoration practices in the Loess Plateau.

The methodology involves stakeholder consultation to identify opportunity mapping, cost–benefit analysis, enabling conditions and financial and investment options (IUCN and WRI 2014). First, adequate local stakeholder consultation on local landscapes and climate could provide important information to feed into mapping of opportunities and perceived challenges. Landscape opportunity mapping needs to be conducted to understand which vegetation types are suitable to the ecological conditions. This may be trees, but alternatively may be grasslands, shrubs or other vegetation depending on the topography, rainfall and soil types. Conducting a diagnostic will enable stakeholders to gauge the key success factors that are in place and not in place and create the foundations for a restoration strategy. Much needs to be done to adequately facilitate and monitor restoration strategies. However, there is a pressing need in China to develop participatory restoration strategies in critically degraded landscapes to ensure sustainable development.

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