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Long-term timber supply from state-owned forests in northeastern China

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SUMMARY

China's state-owned industrial forests, mostly in its Northeast region, are an important source of timber and environmental services in the country. In this paper, we use a break-even price approach to project the long-term timber supply from the state-owned forests in Heilongjiang, the largest timber producing province in the region. Our results show that, at given prices and costs, future sustainable timber production could double the 2006 level and reach the historical high in a full rotation of 40–60 years. This indicates that the region is positioned towards a forest recovery after many decades of over-harvest and decline in mature forest stocks.

Keywords: timber supply, National Forest Protection Program, state-owned forest enterprise, break-even price approach, forest recovery

Production de bois durable des forêts d'état en Chine du nord-est

L. ZHANG, Z. ZHANG, K. ZHANG, Z. ZHANG, X. CHEN, S. ZHOU, G. DAI et D. ZHANG

Les forêts industrielles chinoises propriété d'état, pour la plupart dans le nord-est du pays, sont une source importante de bois et de services environnementaux pour le pays. Dans cet article, nous utilisons une approche estimant des prix de revient équivalents à la dépense pour projeter la production à long terme des forêts d›état dans le Heilongjiang, la province productrice de bois la plus importante dans la région. Nos résultats montrent que le futur d›une production de bois durable pourrait être le double du niveau de celle de 2006 et atteindre une apogée historique en une rotation complète de 40 à 60 ans, en utilisant des prix et des coûts donnés. Ceci indique que la région est orientée vers une guérison des forêts, après plusieurs décénnies de surexploitation et un déclin dans les stocks de forêt établie.

Suministro a largo plazo de madera de bosques de propiedad estatal en el noreste de China

L. ZHANG, Z. ZHANG, K. ZHANG, Z. ZHANG, X. CHEN, S. ZHOU, G. DAI y D. ZHANG

Los bosques de propiedad estatal con fines industriales de China, sobre todo en la región noreste, son una fuente importante de madera y servicios medioambientales para el país. En este artículo utilizamos un enfoque de precio de equilibrio para realizar proyecciones a largo plazo sobre la oferta de madera de los bosques de propiedad estatal en Heilongjiang, la provincia productora de madera más grande de la región. Nuestros resultados muestran que, para unos precios y costos dados, la futura producción sostenible de madera podría duplicar el nivel logrado 2006 y alcanzar su máximo histórico en un turno completo de 40 a 60 años. Esto indica que la región se mueve hacia una recuperación del bosque, después de muchas décadas de sobre aprovechamiento y una reducción de las existencias de bosque maduro.

INTRODUCTION

In the past 30 years, market reforms and economic development have stimulated forest expansion in China where forest area and stock have increased (State Forestry Administration various years). However, most of China's forest expansion has occurred in the non-state (collective) forest regions. The state-owned forests, mostly in the Northeast region, have grown much slower than the national average (Table 1). In fact, three-fourths of mature forests in the Northeast region, defined as forests that have reached legally defined rotation ages, had been harvested before the end of the last century, and the state-owned forest enterprises relying on timber income were in financial disarray and in desperate need of assistance from the Central Government around 2000 (Yin 1998, Zhang 2000). This, plus the disastrous floods in 1998, caused the Central Government to introduce an ambitious Natural Forest Protection Program (NFPP) (Zhang and Magrath 2009, Shen et al. 2006, Yin 2009).

NFPP covers regions that have natural forests and contains various provisions. The most important provisions pertaining to the Northeast include a moratorium from logging

TABLE 1 *Forest land area and timber inventory by ownership, 1981–1998*

	1977–1981	1984–1988	1989–1993	1994–1998*	% (from 1984 to 1998)
Forested area (million hectares)					
State-owned forests in Heilongjiang, Jilin, and Inner Mongolia	33.09	31.88	33.20	35.69	+11.97
Other ownership in the whole country	n.a.	48.06	52.31	67.19	+39.80
Total inventory (million m3)					
State-owned forests in Heilongjiang, Jilin, and Inner Mongolia	2914.14	2798.09	2905.12	3065.29	+9.55
Other ownership in the whole country	n.a.	2219.42	2381.59	2961.46	+33.43

Sources: Ministry of Forestry (various years).
n.a.=not available
* Forested area was defined as land with more than 30 percent tree coverage before 1994 to land with 20 percent or more tree coverage afterwards.

on most state-owned forest lands, increased financial aid to the state-owned forest enterprises, and a requirement that the state-owned forest enterprises solve their internal financial issues by 2010. (State Forestry Administration 2001). Recently, the government has extended the NFPP to 2020. The government hoped that NFPP would lead to a recovery of forest resources and renewed economic growth in the Northeast. The moratorium on the logging on state-owned forests has led China rely increasingly on imports to satisfy its demand for industrial roundwood, which, in turn, has put pressure on the natural forests in other countries that export logs and lumber to China. Therefore, the potential timber supply in the Northeast after the NFPP is a crucial question for regional forest economy, other countries that supply wood to China, and the global environment.

The purpose of this paper is to examine the long-run timber supply potential in the state-owned forests of the Northeast region of China. More specifically, Heilongjiang province, which is the largest timber producing province and contributes nearly half of the timber harvest in the region (State Forestry Administration 2012), is our main focus. Although this study uses the same data as that used in Zhang and Magrath (2009), it differs from the earlier study insofar as it is based on a clearly articulated method and its results are much less rosy than the projections made in the earlier study after errors have been corrected. This paper begins, in the next section, with additional background on forest resources and on policies affecting the forestry sector in the region, followed by approach, data, and results. Finally, the policy implications of the findings on regional forest development and global forest conservation are presented and discussed.

RESOURCE AND POLICY BACKGROUND

China's Northeastern region covers the provinces of Heilongjiang, Jilin, and Inner Mongolia and was the country's most important timber producing region. Between 1949 and 1990, the region accounted for some 50 percent of the country's annual industrial roundwood production (State Forestry Administration 2012). Although the natural productivity of forestland there, at slightly below 3 m^3 per hectare per year, is about the average for the country, the region had once possessed a vast area of natural, old-growth forests. In addition, the region is less mountainous and has always had the advantage of good logging conditions (FAO 2001). In the 1950s and 1960s, the government set up some 80 state-owned forest enterprises there to harvest timber and to manage the forests. Nearly all of these enterprises have integrated operations that include forest management, logging, and wood processing.

Under the central planning system which lasted in state-owned forestry enterprises until the early 1990s, these enterprises were directed to produce timber at fixed prices to support the economic development of the country and to ensure employment through logging operations and forest products manufacturing. Over time, the region's accessible mature and over-mature forest stock declined drastically from 12 million hectares and 2 billion m^3 in the 1950s to 5.6 million hectares and 0.6 billion m^3 in the late 1990s (Zhang 2000). By 1998, 80 percent of the state-owned forest enterprises in the region had little accessible mature resources (Zhang 1998). Consequently, timber production in the region declined from its peak of 30 plus million m^3 per year to about 14 million m^3 in the first decade after 2000.

NFPP seeks to help the enterprises reverse this trend. As noted earlier, it restricts timber harvests from these stated-owned forests, provides financial assistance to the state–owned forest enterprises, and supports reforestation, forest protection, and forest management. Between 2000 and 2010, the accumulative investments under NFPP reached 45.56 billion Yuan (or about US$7.3 billion) in the region (Zhang and Magrath 2008). These investments were for worker compensation, nurseries, and the reforestation of 0.74 million hectares. Further, NFPP gives managers of the state-owned forest enterprises greater discretion over the allocation of their inputs, including employments (Zhang 2000).

Prior to NFPP, the Central Government had already implemented reforms in timber prices, harvesting control, and management in these state-owned forest enterprises. Timber prices have been market-based since 1993; timber harvesting control has been based on calculated annual allowable cut since the 1980s; and management has been based on contracts with managers under a manager responsibility system instead of direct government orders. All of these reforms are intended to incentivize these managers and workers of these enterprises, to protect and grow the forest resources, and to facilitate economic development.

APPROACH

Since NFPP is a major forest policy change, its impact on timber supply is reflected in both the short-term (reduction) and long-term. As we want to assess future and long-term timber supply in this study, the Faustmann approach is the most appropriate approach (Hyde 1980). This steady-state and engineering approach is well suited to estimating timber supply in cases of major change; and it has been used by Vaux (1973), Montgomery et al. (1975), Hyde (1980), and Montgomery and Robinson (1988), among others. The common alternative, broad statistical norms taken from prior production experiences would produce extreme underestimates in cases of major change (Hyde 1980).

Using the Faustmann approach to build the supply function from all known costs and outputs associated with each identifiable forest stand with identical forest growth and yield function and each forest management activity (e.g., natural management, planting, and so on) involves three steps:

First, maximize the economic outcome of a representative unit (typically 1 hectare) of forest under various rotation ages and management regimes:

$$\mathrm{LEV} = \frac{\mathrm{PQ(t, E)e^{-rt} - wE}}{1 - e^{-rt}} \tag{1}$$

Where LEV is land expectation value, P is stumpage price, Q (t, E) is timber volume at rotation age t and under the E amount of silvicultural activity, w is unit silvicultural cost, and r is interest rate. This maximization process generates an optimal rotation age, T*.

Second, calculate the timber supply from the unit of forest and subsequently the total supply from all forest stands that possess identical quality and economic returns:

$$\mathrm{Q} = \frac{\mathrm{AQ(t, E)}}{\mathrm{T^*}} \tag{2}$$

where Q is total timber volume from all sites with identical quality and economic returns, A is the total forest area in hectares that possess identical site quality and economic returns, Q(t, E) continues to represent timber volume from one hectare at the year of final harvest, and T* is the final rotation age. Dividing this volume by the number of years T* in the timber production cycle (the timber rotation) ensures that the calculated volume is sustainable as long as the selected land area remains in timber production and the management practices that led to this harvest volume Q(t, E) continue in their current form.

The price used in step one and the quantity generated in step two provide the matching coordinates for the vertical and horizontal axis of the common economic supply curve.

Finally, this exercise is repeated for all separate forest stands (i.e., each species, land class, and land administrative category). The result is a plot of timber supply from:

- the production level for the least costly activity on all hectares of the most efficiently used land class and species, through
- the second least costly activity on all hectares of the second land class and/or species, through
- the third least costly – and so forth.

This procedure adds an estimated increment of production for each increment in price – with the increment representing a shift to a more intensive management regime of the same species and/or different land class, or to new species in various land classes, as each becomes financially feasible at higher price levels.

However, the optimal rotation age for state-owned forests in China is prescribed by government regulations, which all state-run enterprises must follow. These enterprises harvest timber only when the stumpage revenue (revenue received from delivered logs minus logging and transportation costs) can cover all the accumulative silvicultural expenses (wE in Equation 1). For naturally regenerated stands, the silvicultural cost (wE) only contains the annual management and protection expenses; for planted stands, it consists of planting and tending costs as well as annual management and protection expenses.

In either case, if LEV > 0, the land will fall within the margin of timber production. If LEV = 0, the land is marginal for timber production; and if the land attracts a negative value, it is best allocated to non-timber uses at given expected prices and costs. In other words, for timber production to be economical under the current Chinese regulations, the land expectation value must be greater than or equal to zero. Thus, the economic outcome based on Faustmann formula effectively becomes a break-even price method under the institutional setting in China.[1]

[1] This break-even price approach is a variation or special case of the Faustmann approach in two aspects: (1) the rotation age is fixed rather than being determined through maximizing LEV; and (2) reforestation and management costs (WE in Equation 1) are not determined by profit-maximization principle, either. Both are created under the current Chinese state forest regulations. The latter means that, as the extensive margin of forestry (or logging) is different from the extensive margin of planted forests, some silvicultural investment (WE in Equation 1) should not been made. But, the state forest enterprises make it anyway according to current regulatory requirements and NFPP whereas little silvicultural investment was made prior.

More formally, at the margin for timber production, the break-even method would allow all lands and suitable silvicultural treatments that yield:

$$\text{LEV} = \frac{\text{PQ(t, E)e}^{-\text{rt}} - \text{wE}}{1 - \text{e}^{-\text{rt}}} \geq 0 \tag{3}$$

Since the numerator of Equation 3 is greater than zero, the denominator of Equation 3 must be greater than or equal to zero for the LEV to be greater than or equal to zero. This means the net income from the first rotation must be positive or zero. Thus, the marginal land will become available to supply timber is when

$$\text{PQ(t, E)e}^{-\text{rt}} - \text{wE} = 0 \tag{4}$$

Subsequently, a break-even price point on the timber supply curve can be found by rearranging Equation 4,

$$P = \frac{wEe^{rt}}{Q(t, E)} \tag{5}$$

Equation 5 gives an estimate of the per-unit price (marginal benefit) that is equal to the sum of all compounded management costs for a one-hectare stand at the age of final harvest. It provides a measure of price (or cost) per unit of harvest volume (which is a break-even price), as measured on the vertical axis of an economic supply curve. Again, the corresponding coordinate in the horizontal axis is given by Equation 2.

Although this break-even price method does not maximize economic outcome of forests and we are fully aware of its drawbacks, we use it in this study as a second best method due to the facts that the Chinese state-run forest enterprises have to follow the regulations and that the regulations are unlikely to change in the near future. Under a market economy, silvicultural treatments and final harvest date are decision variables, and given the site quality, expected prices, and costs, there is one silvicultural treatments and one final harvest date which together maximize the LEV. In China, however, silvicultural treatments and final harvest ages are prescribed by the Central Government. Thus, a true market economy has not been implemented in state-owned forest enterprises in China, and we have to work under this constrained institutional setting.

Historically, there have been only two management regimes in the Northeast: natural forests, and planted forests. The former may be used in all stands, while the latter only applied to stands with two dominant species in the region: larch (*Larix cajanderi*) and Mongolian pine (*Pinus sylvestris*). Further, the selection of a single harvest year for each production site implies clear-cutting each final harvest. Small or medium-sized clearcuts, no more than 20 hectares for plantations and no more than 5 hectares for natural forests, are common harvest practices in the Northeast. Indeed, they are common for larch and pine forests throughout much of the world.

Thus, for our purpose, the task is effectively limited to (1) find and include the forest stands (forest sites) that produce positive LEV under the existing management regimes, and (2) if a stand produces multiple LEV under different management regimes, choosing the management regime with the highest LEV. For all these stands, a break-even price is calculated using Equation 5. Of course, similar calculations are necessary for each species and land quality class common to the region. Once each set of calculations is completed, we have a series of coordinates. Arraying these from the least to most costly per unit of volume creates the anticipated sustainable supply curve for the whole region – which shows the sustainable harvest volume forthcoming for any particular cost (price) per unit of timber volume.

DATA

The data for the analysis come from a survey of actual and historical timber management and harvest experiences in Heilongjiang province in 2006. The survey was conducted in 2007 and is described in Zhang and Magrath (2008). Heilongjiang province as a whole contains almost 20 million hectares of forests, which account for 45 percent of the forest area in the three Northeastern provinces. State-owned forests, the administrative category likely to be most responsive to policy reform in the Northeast accounts for 93 percent of the Heilongjiang forests. These state-owned forests are further sub-divided as commercial (or productive) and ecological forests. The latter are protected for various environmental and other social values. Although limited amounts of timber management and harvesting are possible on ecological forests, we exclude them from this study. In total, 79 percent of Heilongjiang's state-owned forests, or almost 14 million hectares, are classified as productive forests and available for timber harvest and management (State Forestry Administration 2005). In addition, some 0.7 million hectares of productive forests are owned by the provincial government (State Forestry Administration 2005), which are also included in this study and which account for 4.8% (0.7/14.6) of our total study area.

There are four major forest regions in the province: Daxinganling mountains, Xiaoxinganling mountains, Wandashan mountains, and Changbaishan mountains. The commercial timber species or forest types include poplar (*Populus adenopoda*), larch (*Larix cajanderi*), birch (*Betula platyphylla*), Mongolian pine (*Pinus sylvestris*), Mongolian oak (*Quercus mongolica*), and four other types with mixed species. Forest land falls into five productivity classes, I-V, with I being the most productive. As noted earlier, all species/forests have natural stands that receive minimal management inputs on most sites. However, two species, larch and Mongolian pine, have plantations and produce greater harvest volumes on some sites. Theoretically, there are 220 forest types [(9 natural stands + 2 plantation stands) × 5 classes × 4 regions] in the province. However, not all forest regions in the province have all the forest types and site classes. In the end, there are a total of 158 representative forest types.

For each of the four forest regions in the province, one state-owned forest enterprise and one forest bureau (the latter being provincially operated) are selected (Table 2), and

TABLE 2 *Forest regions in Heilongjiang province and state-owned forest enterprises and forest bureaus included in our sample*

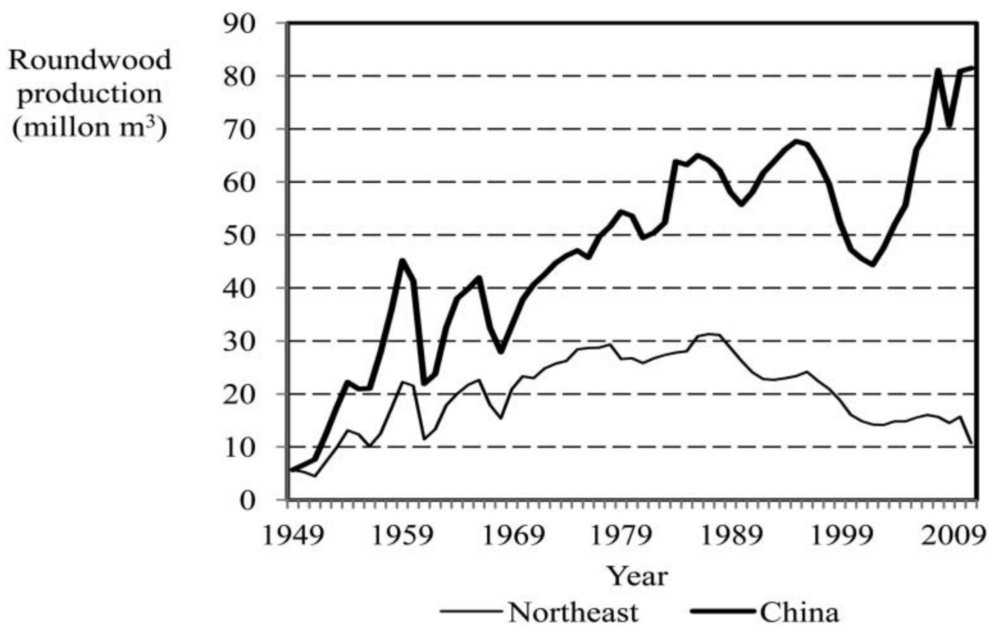
Forest region	Administrative Unit
Daxinganling Mountains	Xinlin Forest Enterprise Tahe Forest Bureau
Xiaoxinganling Mountains	Tieli Forest Enterprise Yilan Forest Bureau
Wandashan Mountains	Dongfanghong Forest Enterprise Baoqing Forest Bureau
Changbai Mountains	Hailin Forest Enterprise Muling Forest Bureau

information for all forest types in the selected enterprises and bureaus is collected. For every representative type of forest, there are 5–10 observations (stands) from each state-owned forest enterprise and 1–3 observations from the forest bureau in the same region of the province. The historical cost and current/potential yield data in each observation are obtained.[2] The differences among the multiple observations for each one of the representative forests are generally small, and an average is used in the calculations for the representative forest type in each region.

Our measure of timber yield is the standing timber volume currently observed at the rotation age of harvest. The final harvest levels for each timber stand are divided by the number of hectares in the stand to create a measure of yield for a standard one-hectare timber stand. The one-hectare yields in the observed timber rotation are then divided by the number of years to obtain an average annual sustainable yield in m^3 for the standard one-hectare stands of each site and species/forest type class. Finally, the number of m^3 is multiplied by the total number of hectares in the province corresponding to that site and species/forest type to obtain the sustainable yield for Heilongjiang province for that site and species/forest type. Again, this is the horizontal coordinate in the long run sustainable economic supply curve.

As these yields are results of historical management practices and are estimated at the legal rotation ages, they might underestimate the expected future yields from stands that will have benefitted from a full growth period at the new higher level of management and advanced silvicultural techniques. Further and as noted earlier, the cases that optimal rotation ages deviate from the legally defined ages are not considered.[3]

FIGURE 1 *Industrial roundwood production in the Northeast region and the country: 1949–2011*



Data sources: State Forestry Administration (various years)

2 This cost and yield data is found in the Forest Resource Files of the enterprises and forest bureaus listed in Table 2. These files are composed of numerous cards or pages for every forest stand (also called forest subcompartment). Each stand is a land unit of a relatively uniform forest. The files for each stand report stand age, species or forest type, current standing volume, management activities, and costs. For example, card No.48-2 means stand No.2 in forest compartment No.48. The stand has 5.8 hectares of 41 year-old larch plantation, and its site class is II. Since this stand is not at the final harvest age, the current standing inventory and costs for this stand are projected to age 60 when final harvest is expected to begin.

3 In practice, there are variations in rotation ages for similar forest types and site classes in different forest regions in the Northeast. However, we have found that the average of actual rotation ages is about the legal rotation ages.

Similarly, our measures of annual costs for each category of forest stands are taken from the historical financial management records of the forest enterprises and forest bureaus. Costs range from the cost of general annual oversight plus annual costs for preventing and controlling fires and insects in natural stands, to site preparation, planting, and tending for planted stands. The cost (break-even price) per cubic meter of sustainable wood for each site and species/forest type class is then calculated based on Equation 5. On the other hand, the time lag in natural regeneration is not considered which may overestimate the timber supply.

For all these reasons, we believe that our results are an approximation of the long-term sustainable timber supply in the province (and the Northeast region). Our interest rate is 4 percent, which is approximately the real cost of capital used by the World Bank for its forestry lending programs in China (e.g., World Bank 1990). Although this rate is an annual rate while the interest rate in Equation 5 should be a continuous interest rate, the difference between them is really small in our case, because the continuous rate is Ln(1.04) = 3.9221%. Thus, the 4% rate is used as the continuous rate in this paper. However, a sensitivity analysis to this rate and with different silvicultural costs is conducted.

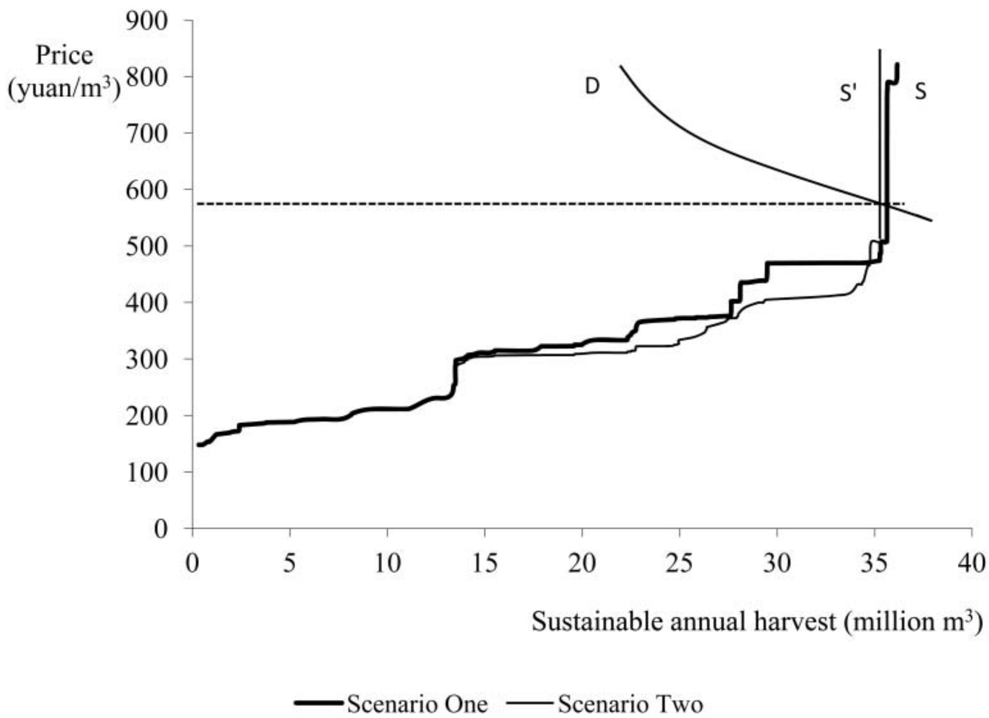
RESULTS

Figure 2 shows our results – the price in yuan per m^3 at which each species/forest type becomes economically harvestable and the corresponding accumulative sustainable annual harvest volume of standing timber. In essence, under the existing management regimes prescribed by the Central Government and implemented by the state-owned forest enterprises, the long-term timber supply could reach 36.58 million m^3 per year from 14.6 million hectares of timberlands in the province (Scenario One in Figure 2). Of which, some 34.83 [or 36.58*(1–4.8%)] million m^3 per year are from state-owned forests. The average yield of standing timber is around 2.51 m^3 per hectare per year.

However, not all timber stands are profitable under the current management regimes and price expectations, even though they are legally classified as productive forests. Thus, it is appropriate to remove those stands with negative LEV from timber production. Further, even though the plantation stands produce higher volumes than natural stands, some plantation stands actually have a lower LEV than their corresponding natural stands. This is because the costs of tree planting and tending, carried for the entire rotation age, have a bigger negative impact on LEV than the positive impact of increased timber volume. For these stands, the yields and management regimes of natural stands in future rotations are used. Incorporating these two considerations would cause the long-term sustainable timber supply to reduce to 35.21 million m^3 (of which, some 33.52 million m^3 are from state-owned forests), and the long-term timber supply to a slightly lower level (Scenario Two in Figure 2).

Using a recovery factor of 0.6, this standing timber supply means that some 21 million m^3 of roundwood (logs) could be produced annually. For comparison, the historical peak of roundwood production was 18.8 million m^3 (or 18.8/0.6 = 31.33 million m^3 of harvestable standing timber) in 1988. And in 2006, the annual roundwood production from state-owned

FIGURE 2 *Estimated sustainable timber supply in Heilongjiang province using 4% interest rate*



Note: D= demand; S=supply under Scenario One; S′ = supply under Scenario Two forests in the province was 8.72 million m^3, and the weighted average of stumpage prices were 578 yuan per cubic meter (1 yuan = US$ 0.16). Thus, should the expected stumpage prices stay at this level in the future, the sustainable, long-term timber (and roundwood) supply could be slightly higher than the highest level reached in history and 2.5 times the 2006 level.

Figure 2 shows that sustainable timber supply is relatively elastic in a broad range between 14.53 million m^3 (8.72/0.6, which was the harvest level of standing timber in 2006) and 35 million m^3 per year. This result (supply elasticity being approximately 1.5) is comparable to other findings of long-run timber supply elasticities in Hyde et al. (1991) and Buongiorno et al. (2003). Only the poorer productivity sites and less productive species/forest types remain available to add productivity above 35 million m^3 per year. These sub-marginal stands add little to annual production and only at much greater costs. Therefore, output becomes very inelastic as these stands are added.

Figures 3 and 4 present the results of the sensitivity analysis. Figure 3 repeats the results for the 4 percent discount rate (Scenario Two) and shows the comparative results at 3 percent and 5 percent. Consistent with theory, timber supply increases when the cost of capital declines, and vice versa: if the interest rate is 3 percent, virtually all sites included in this study become profitable in timber production. On the other hand, if the interest rate rises to 5 percent, the annual long-term sustainable timber supply falls to about 23.44 million m^3, (not shown in Figure 3). This low supply was because nearly all plantations become less profitable than natural forests (and even have negative LEV), some natural forests have a negative LEV, and all planted and natural forests with negative LEV are removed from timber production. If plantations are replaced with natural forests and only these natural forests with negative LEV are not considered, the sustainable annual timber supply would rise to 31.20 million m^3, as shown in Figure 3.

As labor costs have been rising in China, it is only considered that the silvicultural costs would be 50% higher (Figure 4). Not surprisingly, the results show that, with this increase in silvicultural costs, nearly all forest plantations have negative LEV and become less profitable than natural forests, and some 15–20 percent of natural forests become uneconomical. Replacing plantations with natural forests and removing uneconomical natural forests make the long-term sustainable timber supply about 31.10 million m^3 per year.

Thus, even with these adjustments in capital and silvicultural costs, the projected sustainable annual output remains elastic in the range of 14.53 to 31 million m^3, and most of it is available at the 2006 stumpage price level. These results, again, suggest that doubling the annual timber production from the 2006 level is possible in Heilongjiang once the forests fully recover.

CONCLUSIONS AND DISCUSSION

In this paper, the break-even approach and historical data are used to project long-run sustainable timber supply for the state-owned forests of Heilongjiang province in Northeastern China. Our results suggest that, if the expected stumpage prices stay at the 2006 level and management intensity remains at historical levels, the long-term sustainable timber supply could reach 30 to 35 million m^3, which is about twice

FIGURE 3 *Sustainable timber supply in Heilongjiang province: Sensitivity to alternative interest rates*

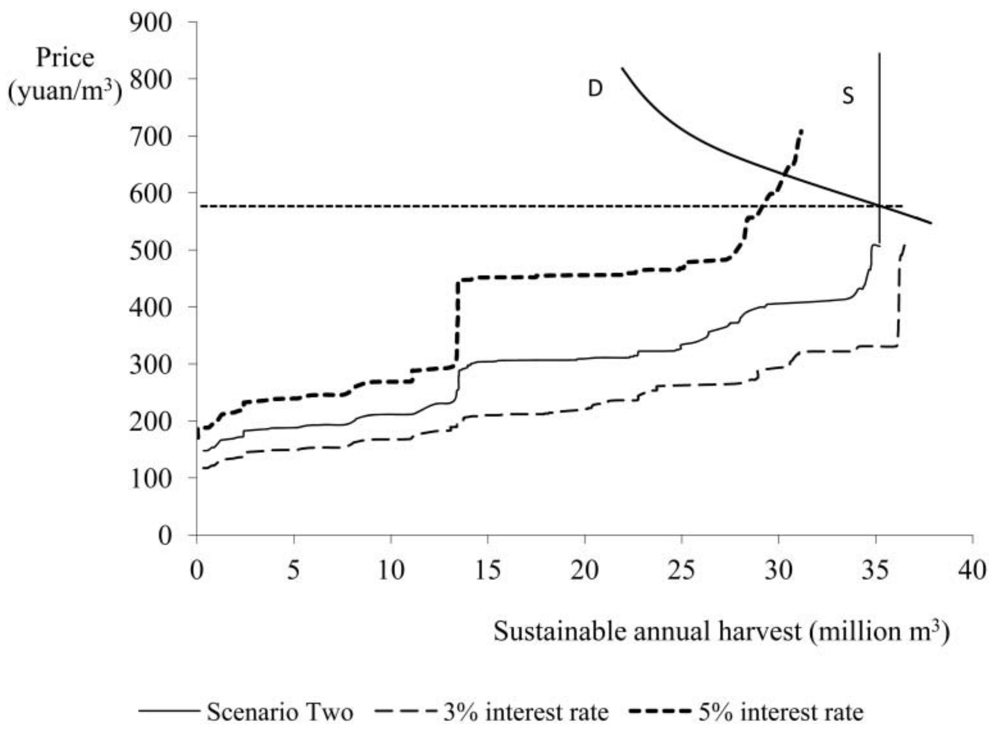
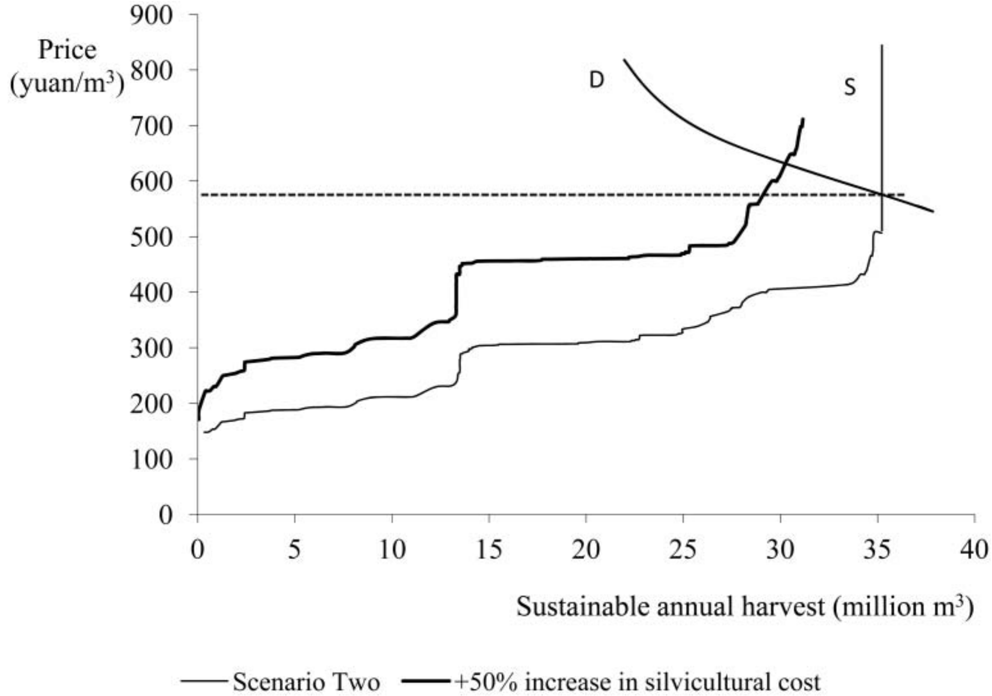


FIGURE 4 *Sustainable timber supply in Heilongjiang province: Sensitivity to a 50% increase in silvicultural cost*



the timber harvest level in 2006, or slightly surpass the historical peaks. Thus, once the forests in the provinces recover, they can be very productive and capable of a much greater level of timber production, and, thereby, capable of supporting a strong regional forest industry and contributing to a strong aggregate economy in the province. Our sensitivity analyses show that, even if the silvicultural cost increases 50 percent, the long-term standing timber supply in the province could reach 31 million m^3 per year.

The policy implications of our results are three fold. First, for a region where many years of over-harvest have largely depleted its mature and natural forests, the future of forests and the forest industry is bright. As long as timber harvests do not exceed the sustainable timber yields, adequate investment is made in forest protection, and silviculture remains at its historical level in the coming decades, it's expected that eventually timber harvests will reach and even surpass the historical peak in the region after a full rotation of 40–60 years. Also, a recovery of forest industry and employment of a similar magnitude will follow. Staying with the limit of the sustainable harvests is important to avoid the past experience of unsustainability.

Second, NFPP has allowed the forests to recover to a certain degree and the enterprises to reform their own internal operations. Our estimated results show the sustainable timber production level that could exist after the forests recover and the reforms are fully implemented. Given the seriousness of resource depletion and lack of silvicultural investment in the previous decades, NFPP should perhaps last a little longer than the government had envisioned, that is beyond 2020.

Third, the recovery of the forests and forest industry in the major timber producing region of China would ease the country's demand for timber from overseas. In other words, we could see China's domestic timber replace some of its imports. This will undoubtedly have some local and global environmental benefits.

It's also found that some productive forests are not profitable given the expected prices and costs. Thus, the best use for these forests is to not produce timber, but rather non-timber benefits. Further, some government silvicultural prescriptions actually reduce the profitability of the forest stands. It is thus recommended that the government forestry agency and the forest enterprises shall examine this issue and make proper adjustment in the official silvicultural prescriptions for various land qualities. Finally and perhaps most importantly, rather than relying on fixed rotation ages for many species and timber stands that was determined some 40 years ago, the government should examine the economic rotation ages of various forest types and land quality and revise its timber harvesting regulations. Indeed, it is surprising that the economic rotation ages of state-owned forests have not been estimated after 30 years of economic reform and the operation of a market based economy in many other sectors of the country's economy. Perhaps the forest enterprises should have been given more freedom in determining the rotation ages of the forests under their management.

Our results are based on current forest yields, historical production costs, and timber prices that are expected to be stable in real terms for the future. Any changes in these variables would result in variations in our forecast. In particular, technology changes such as genetically modified seedling, and an increase in silvicultural investment could enhance timber yields. For example, most of the forest stands in this study have not been thinned; and those few that have been produced little income, which has not been considered here. Yet, the government has recently emphasized forest tending and thinning in national forests. If forest tending and thinning are widely used in the Northeast, that would alter the production function of the forests as well as the rotation lengths. On the other hand and as noted earlier, reforestation lags in all the natural stands are not considered, which could lead to an overestimate of timber supply. These issues notwithstanding, we are confident that the long-run timber yields from the region would be substantially higher than the level of timber harvests we have observed in recent years. A strong recovery of the state-owned forests is projected in the coming decades and an elevated level of annual timber production once forests recover in the region.

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