Figures in *Forest Economics*
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To accompany *Forest Economics* by Daowei Zhang and Peter H. Pearse
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Figure 1.1: A forest's economic value

- Total value of a forest
  - Extractive value
    - Timber value (e.g., industrial timber, fuel wood)
    - Non-timber value (e.g., fruits, nuts, mushrooms, livestock fodder, game)
  - Non-extractive value
    - Ecosystem (environmental) service value (e.g., soil and water protection, biodiversity, climate mitigation)
    - Preservation value (e.g., existence value, option value, bequest value)

Figure 2.1a: Relationship between output and inputs

Figure 2.1b: Relationship between output and labour

Response of total output to changes in labour input when capital and other factors are held constant.

Figure 2.1c: Relationship between output and labour: Law of diminishing marginal products

Figure 2.1: Relationship between output and inputs

Figure 2.2: Isocost curve for capital and labour

Figure 2.3: Expansion path of efficient input combinations

Figure 3.1: Decision tree for a pest control project

Figure 3.2: Correct and incorrect match of interest rate and timber price in forest investment analysis

<table>
<thead>
<tr>
<th></th>
<th>Real price</th>
<th>Nominal price</th>
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<tbody>
<tr>
<td>Real interest rate</td>
<td>√</td>
<td>× (inflates the returns of forest projects)</td>
</tr>
<tr>
<td>Nominal interest rate</td>
<td>× (biased against forest projects)</td>
<td>√</td>
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√ = correct match, × = incorrect match.

Figure 3.3: Value of a pre-merchantable loblolly pine timber stand: Difference between discounting at age 30, when the stand is ready for a final harvest (valued at B), and at age 15, when the stand just becomes merchantable (valued at A)

Figure 4.1: Market supply, demand, and net value of a forest product

Figure 4.2: Relative elasticity and welfare change resulted from an increase in supply

Figure 4.3: Linkage among stumpage, log, and forest products markets

Figure 4.4: Prices for softwood lumber, sawlogs, and sawtimber stumpage in the southern United States: 1955-2001 (MBF = thousand board feet)

Figure 4.5: Derived demand for pulpwood in newsprint production

Figure 4.6: Timber demand and supply for timber in short and long-run

Equilibrium price

Demand

Short-run supply

Long-run supply

Very long-run supply

Quantity of timber demanded and supplied per period

Figure 4.7: Long-run supply response when demand shifts upward

Figure 4.8: Relationship between net value of timber and economically recoverable inventory

Figure 4.9: Long-run timber supply projection

Figure 5.1: Market demand and consumer surplus

Figure 5.2: Equilibrium level of recreation consumption at two levels of fixed cost

Figure 5.3: Zones of travel origin to a recreational site

Figure 5.4: Derivation of the demand curve for a recreational site from travel costs

Figure 5.5: Effect of crowding on demand for a recreational opportunity

Figure 6.1: Efficient application of labour to a forest site

- Value of the forest crop ($ per hectare)
- Marginal revenue product of labour ($)
- Quantity of labour (person-days)
- Payment to labour
- Land rent
- Wage
- Efficient quantity of labour

Figure 6.2: Relationship between price of timber and productive timberland

Figure 6.3: Efficient allocation of land among different uses

Figure 6.4: Types of production possibilities for two products on a tract of land

A. Competing uses

B. Mutually exclusive uses

C. Highly conflicting uses

D. Constantly substitutable uses

E. Independent uses

F. Complementary uses

Figure 7.1: Growth in volume and stumpage value of a forest as it increases in age

- Value or volume of timber
- Average and incremental growth in value ($ per hectare per year)
- Rate of growth $\Delta S/S(t)$ in stumpage value (% per year)
- Optimal harvest age for a single crop

$S(t)$

$Q(t)$

$\Delta S$

$\Delta S/S(t)$

$\Delta S/S(t)$

$S(t)/t$

$\Delta S$

$S(t)$

$Q(t)$

$\Delta S$

$\Delta S/S(t)$

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$Q(t)$

$\Delta S$

$\Delta S/S(t)$

Figure 7.2: Optimal economic rotation for continuous forest crops

Annual costs and returns ($)

Incremental growth in value $\Delta S/S(t)$

Incremental cost, including land

\[ \frac{i}{1 - (1 + i)^{-t}} \]

Rotation age (years)

Figure 7.3: Incremental growth in value and costs with stand age

Figure 7.4: Relationship between stand age and various amenity values

Figure 8.1: Per-acre annual growth, removal, and inventory on private timberland in the US, 1953-2007

Figure 8.2: Age-class distribution of inventory in private timberland in western Oregon, 1997

Figure 9.1: Forest area in the United States by region, 1630-2002

Figure 9.2: Real price indices for lumber and stumpage, in terms of 1992 prices (1992 = 100)

Figure 9.3: The Erie Canal

Figure 9.4: Optimal reforestation effort, $E^*$, changes when stumpage price increases

\[ P^0 Q_E e^{-rt} \quad P' Q_E e^{-rt} \]

Cost or expected revenue per unit of effort ($/E$)

Marginal revenue product

Figure 9.5: Private tree planting in the US South by ownership, 1928-2003

Marginal benefits associated with pulp output

Marginal costs imposed on fishermen

Marginal benefits associated with pulp output

Output per unit of time

Figure 10.1: The Coase Theorem

Figure 10.2: Degrees of exclusiveness of forest tenure

Types of forest tenure

- Multiple quota rights
- Harvesting permits
- Licences
- Leases

Degree of exclusiveness

- Reserves for special users
- Restricted users
- Stinted users
- Exclusive users
- Complete property
- Freehold

Common property - sole property

Uncontrolled access

Unlimited users

No property
Figure 10.3: Combinations of attributes in forest property

Figure 11.1: Effect of a royalty or severance tax on the range of log quality that can be profitably harvested.

Although the next two graphs (Figures 11.1a and 11.2b) do not appear in *Forestry Economics*, the material in these graphs are discussed on page 315 of the book. They are presented here to facilitate teaching and help students understand the relevant discussion on yield taxes.

Figure 11.1a: Effect of a yield tax that applies to the gross value of logs on the range of log quality that can be profitably harvested

Figure 11.1b: Effect of a yield tax that applies to the net value of logs on the range of log quality that can be profitably harvested.

Figure 11.2: The relative burden of tax

Figure 12.1: Global export volume of different forest products, 1970-2006

Figure 12.2: Determination of price and quantity of plywood to be imported and exported when trade is free, transportation costs are negligible, and all else remains constant

Figure 12.3: US outward and inward foreign direct investment in forest industry in constant 2000 US$, 1983-2008

Figure 12.4: Canadian outward and inward foreign direct investment in forest industry in 2000 constant CND$, 1983-2008

Figure 13.1: The Environmental Kuznets Curve

Figure 13.2: Direct and underlying causes of tropical deforestation

**Direct causes**
- Natural causes
  - Hurricanes
  - Fires
  - Pests
  - Floods
- Resulting from human activity
  - Agricultural expansion
  - Cattle ranching
  - Logging
  - Mining and oil extraction
  - Construction of dams
  - Roads

**Underlying causes**
- Market failures
  - Unpriced forest goods and services
  - Monopolies and monopolistic forces
- Mistaken policy interventions
  - Wrong incentives
  - Regulatory mechanisms
  - Government investment
- Government weakness
  - Concentration of ownership
  - Weak property rights arrangements
  - Illegal activities and corruption
- Broader socioeconomic & political causes
  - Population growth and density
  - Economic growth
  - Distribution of economic and political power
  - “Excessive” consumption
  - Global warming
  - War and political instability