Part III Resource Worlds

Chapter 14

Resources

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Natural resources are "factors of production." That is, they are employed along with labor and other forms of capital in producing goods and services. The economic geography of natural resources, the places of their production, and the places of their consumption, is fundamentally different from the economic geography of most other production factors. That difference results because unlike labor, unlike machines, and unlike buildings, natural resources actually exist as a form of interaction between the physical environment (nature) and society.

This chapter takes up the economic geography of natural resources using a recurring theme: resources have technological and cultural contexts for their evaluation. That is, there are certain technological and/or social conditions that have to be met before a part of nature is considered valuable in production. The chapter begins with a basic overview of natural resource geographies, focusing on their recognition, classification, and description. The second part of the chapter turns to the analysis of the relative valuation of natural resources using the principle of economic rent, and considers the question of the supply and demand for resources in market economies. The role of technology in effecting economic rent and, therefore, natural resource supply is emphasized. Rent-maximizing behavior on the part of producers is a primary determinant of the locational pattern of resource extraction, which in turn has important implications for natural resource-based economies. Those implications are considered in the third part of the chapter, which ends with a brief discussion of the potential for such economies to achieve sustainability.

Defining and Classifying Natural Resources

In an often-cited statement (e.g. Cairns, 1994, p. 782), Erich Zimmerman wrote "resources are not; they become." The implication is that natural resources are not pre-given, natural factors around which society fashions its production processes, but rather their usefulness is conditioned by cultural, historical, technological (and other knowledge), and geographical circumstances.

For example, almost all of the mineral resources have a technological context to their value. Rees (1989) cites bauxite, for example, which wasn't recognized as a true resource until 1886 when technology was introduced that allowed it to yield alumina (an intermediate resource that is further refined to aluminum). Uranium is another example. It didn't gain significant commercial value as a resource until nuclear fission became controllable. By the late 1950s, uranium ore was highly sought after and was expected to increase in commercial use, and value, as nuclear technological abilities continued to grow. A changing cultural context, however, one in which the environmental and public health costs of using uranium as a resource have become increasingly recognized, has reduced the value of uranium considerably since the late 1970s. Silica, on the other hand, has been recognized as a significant resource in glass production for centuries. Its recognition and value as a resource has increased significantly in about the last 20 years, however, as digital technology has developed and technological change has replaced vacuum tubes with transistors, and transistors with silicon chips.

The same kinds of changing societal contexts affect the recognition of non-mineral resources, too. Wetlands, for example, used to be considered nothing more than sources of disease and land gone to waste. Today, we think of wetlands as valuable protective buffers to flood waters and natural water purification systems. Today, many people are concerned with loss of forests. Beyond their use in goods production, they are a valuable resource that diminishes climate change and provides critical habitat in support of biodiversity. On the other hand, the historian David Landes (1998) writes of the former forests of Northern Europe as a surmountable *barrier* to that region's economic ascendancy.

Once natural resources are recognized as factors of production, they are often described by their supply characteristics. For example, resources are often classified with respect to being exhaustible or renewable. Exhaustible resources are those environmental factors that have a fixed terrestrial or oceanographic supply and therefore will be completely consumed if current rates of use continue. Renewable resources are not in such fixed supply. They may be biotic – forests, for example, or fisheries. Other renewable resources effectively have astrophysical sources, for example winds, tides, and solar energy. The supply of renewable resources is *potentially* limitless over time, precisely because of their renewable quality. While this is true enough for astrophysical resources, it is harder to support in the cases of biotic resources which may, in fact, become exhausted.

The amount, or stock, of a resource is also classified into a series of components (Harris, 1993). The first part is cumulative production, or the amount of the resource that has already been extracted and is, therefore, no longer available. The second part of the stock consists of *reserves*, which include the amount of the resource that is available using current technology and at current prices. The third part of the stock consists of *potential supply*, an effective estimate of future reserves. It is the amount of the resource that will be available if reasonable expectations of technological advance are achieved and/or prices increase. The *recoverable resource* is the combination of reserves and potential supply. It is evident that this classification of resource stock components rests on a technological context and also a context of market preferences as indicated by resource prices.

Because they have both technological and market contexts for their definition, resources don't necessarily decrease over time. Often, as technology and/or prices change, that part of a stock that is potential supply is added to that part that is in reserve at a faster rate than is taken in production. If that occurs, reserves increase rather than shrink. For example, worldwide proven reserves of crude oil increased from about 650 billion (1,000,000,000) barrels in 1975 to about 765 billion barrels in 1985, and then increased to about one trillion (1,000,000,000,000) barrels by 1995 (*Annual Statistical Bulletin 1995*, 1996). That increase in reserves took place concurrently with ever-higher volumes of consumption. It's as if petroleum reserves are increasing the more that they are consumed.

In addition to technological and market contexts, there is also the geographical one. For example, proven oil reserves increased at the global scale from 1975 through 1995, but the record was very uneven at the regional scale (table 14.1). Asia's reserves increased consistently over the period (and will continue to do so as the oil fields of the Caspian Sea region are developed), and so did the reserves of Latin America and the Middle East. In addition, Africa's and Oceania's reserves were greater in 1995 than in 1975. Reserves in Europe and in North America, however, were lower in 1995 than in 1975. Reserves in those regions have declined as a function of actual use. Both those regions exhibit a production history that is common and often predictable (World Resources Institute, 1996, pp. 276–7). Most regional production increases until about one-half of its recoverable resource has been extracted: it peaks at that point, and then begins a decline (see "Natural Resource Economies" below for a description of the related regional economic impacts of the production pattern).

Induced initially by industrial demand and then additional consumer demand, recoverable petroleum resources were developed in Europe and North America early on (by international standards) and drawn down early on as well. Petroleum resources were developed more recently in other regions of the world, so their reserves continue to grow as much by virtue of their economic history as by a fortunate geology. The same geographical pattern of recognition – core regions early, peripheral regions late – is common to a large variety of natural resources (Porter and Sheppard, 1998, pp. 214–18). Even though regional resources decline in supply, it's not necessary that regional consumption follows the same pattern. For example, Asia, Western Europe, and North America are regions with more oil

Table 14.1 World proven crude oil reserves by region, 1975, 1985, and 1995 (thousand million barrels)

Region	1975	1985	1995
Africa	59.1	56.2	75.5
Asia	36.6	36.8	42.0
Eastern Europe	61.9	64.4	59.1
Latin America	36.1	118.6	131.6
Middle East	387.1	431.9	665.1
North America	39.7	33.9	31.7
Oceania	2.0	1.7	2.2
Western Europe	25.6	22.2	21.1

Source: *Annual Statistical Bulletin 1995* OPEC (1996)

Table 14.2 World crude oil production, refining, and consumption by region, 1995 (thousand barrels per day)

Region	Production	Refining	Consumption
Africa	6,256.4	2,175.1	1,804.5
Asia	6,132.1	13,284.2	15,220.0
Eastern Europe	7,193.0	5,984.5	5,644.8
Latin America	7,725.0	5,964.1	5,762.8
Middle East	18,856.3	4,826.1	3,225.4
North America	7,936.1	17,560.4	17,910.9
Oceania	640.0	855.4	643.3
Western Europe	5,743.9	14,133.7	12,617.8

Source: *Annual Statistical Bulletin 1995* OPEC (1996)

refining than oil production, and more oil consumption than oil refining (table 14.2). Africa, Eastern Europe, Latin America, and most notably the Middle East follow the opposite pattern.

It appears that the location of resource deposits is almost irrelevant to where geographically those resources will be used. That irrelevance is not new, but is the result of the historical importance of the cultural, technological, and market contexts for resource recognition. In the past, industrial cities such as Pittsburgh didn't arise only because of proximate raw material deposits of coal, iron ore, and limestone (for steel production, in Pittsburgh's case). After all, there are many raw material deposits around the world that were known in the nineteenth century but are yet to be "developed" into centers of manufacturing. As noted by Paul Bradley, "some resources 'become' better than others" (Cairns, 1994, p. 782). At the time, the right technology, the right culture, and the right markets, were in the right proximity to recognize the natural resources that certainly facilitated the growth of Pittsburgh. It wasn't the natural resources alone.

Economic Rent and the Exploitation of Natural Resources

One of the earliest and most influential economists to examine resource exploitation was David Ricardo, who wrote in England in the early nineteenth century. Ricardo was most interested in the relationship between crop prices and land prices, but his analysis of their interaction can easily be extended to most natural resources. At the time, a generally held view was that the price of food was high because agricultural land was so expensive. Tenant farmers needed to charge high prices for their products, particularly corn, to cover the high land rents charged by landowners. Ricardo demonstrated that, in fact, the opposite relationship held; the price of land was high because food prices were high. As food prices rose, farmers expanded their production through a process of more intensive cultivation of land already in agriculture and by expanding crop production to land previously left unused for cropping. Ricardo argued that as food prices rose, more and more land could be expected to undergo development for agriculture. In a sense, as prices rose, agricultural land "became" more and more of a natural resource.

Some land "became" a resource better than other land, however, because not all land is suitable for agriculture, and some pieces of agricultural land are better than others. Ricardo observed that qualitative differences in land as a result of differential soil fertility or irrigation requirements had an important bearing on the profits generated from farming. He analyzed variations in land profitability in terms of *economic rent*, a payment over and above what is necessary to stay in business. Rent is defined by the identity:

$$R = Q \cdot (p - c) \tag{14.1}$$

Where R stands for economic rent, Q represents quantity of production (kilograms for example), p is price per unit (kilo) paid in the marketplace, and c is the cost per unit (kilo) of production. As long as a piece of land's economic rent is positive, a farmer can pursue agriculture on it. In contrast, if the economic rent is negative it would imply that costs (Qc) are greater than revenue (Qp) so that farming would be uneconomical.

Ricardo was concerned with what is called *differential rent*, or the difference in rent that is earned by farmers with better agricultural land compared to the rent that is earned by farmers with land of lower quality (Bina, 1989). As food prices rise, farmers of better land enjoy rent increases in greater amounts than would accrue to farmers of poorer land. Because all rents rise with an increase in market prices (or as p increases relative to c in equation 14.1) the market value of land rises as well. The best land has the highest rent and price, and as the quality of the land decreases so do rents and prices.

Differential rents increase as food prices rise. This is because as prices rise additional lower quality land is brought into production as a result of the higher demand for the agricultural good. The consequence is that the difference between the revenue (Qp) generated by the best quality land and the worst quality land increases. That difference, though, is the very basis of differential rent. Hence, as food prices increase so do differential rents.

The shift of the analysis from agricultural land to natural resources in general is easy to make. As described above, reserves of oil, and most other mineral resources for that matter, have been increasing over time. One explanation for such increases is Ricardian; higher prices paid at the market have allowed lower and lower quality portions of stocks to become recoverable resources. Price increases of the type Ricardo observed are often illustrated as a demand shift, which can lead to an explicit expansion of resource production and an implicit expansion of reserves.

Such a shift is shown in figure 14.1, which is a simplified representation of an idealized market for a hypothetical natural resource. Supply of the resource to the market is shown to increase as price rises, indicating not only that more of the resource is produced, but also that it is being produced from more locations. The supply line represents the cost of production (c in the economic rent identity). In a geographical context, its lowest point represents production at the lowest cost location: the place where resource "quality" is the highest. Rising from the lowest point, the supply line indicates that more of the resource is being produced, but at increasing cost as lower and lower resource quality locations are exploited. The limit of production is defined by the price offered for the resource (p in the economic rent identity). Where price and cost are the same, economic rent is equal to zero, so that point defines not only the aggregate quantity of resource production but also the *marginal location* – that place with the lowest quality resource that will be exploited. Where the price is higher than the cost of production, as defined by the supply line, rent is positive. Rent is at a maximum where the gap between the price line above and the supply line below is at its greatest, or at the location associated with the resource's highest quality. Rent decreases as resource quality declines, and the gap between the price line and the supply line narrows and disappears at the marginal location.

The supply line slopes upward in figure 14.1 because more of the resource will be produced at higher prices. Conversely, the demand lines slope downward because higher prices make use of the resource less attractive. The demand lines represent the willingness-to-pay for using the resource. Some people are willing to pay high prices for the resource, but more people would prefer to pay lower prices. Market equilibrium is defined where the demand line crosses the supply line. That intersection defines the price at which the market is "cleared," with the amount of the resource in demand and the amount supplied equalized.

The type of demand shift illustrated in figure 14.1, in which demand rises from level 1 to level 2, could result from population growth (as concerned Ricardo) or even a change in consumer preferences. It indicates a general increase in the willingness-to-pay for the resource that has an impact on both the quantity consumed, at least in the short run, and also the locations of resource exploitation. As the higher market price for the resource is realized, the differential rent (again, price minus cost) increases at the higher-quality resource locations and economic rent is generated in places where it could not have been extracted under the earlier lower price. Ricardo described poorer and poorer quality agricultural land being cultivated as increasing population resulted in increasing food prices. In figure 14.1 the story is similar, with poorer quality resource locations being exploited as the willingness to pay for the resource increases.

Not only can we think of resources and their locations of exploitation "becoming" because of growth in demand, but we can also think of them becoming from the "supply" side, with technological change playing an important role. For example,

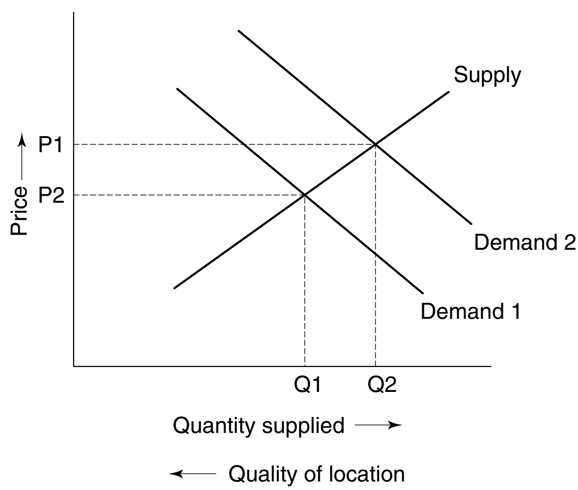

Figure 14.1 An upward demand shift

characteristics such as soil quality or soil moisture can be augmented by capital investment (in fertilizer and in irrigation systems, respectively). Bina (1989, p. 91) quotes Marx as writing, "There is no doubt that as civilization progresses poorer and poorer kinds of land are brought under cultivation. But there is also no doubt that, as a result of the progress of science and industry, these poorest types of land are relatively good in comparison with the former good types." Like Ricardo, Marx had observed that differential rent not only increased because of increasing prices, but that capital investment and technological advance could also cause rents to increase by lowering the costs of production – the supply side of the rent identity in equation (14.1).

It appears that technological change has a profound impact on resource recognition and quality – on resources "becoming" (Dasgupta, 1993). Technological innovations allow resources to be used for particular purposes (silicon, for example). Technological change permits the development of new materials. It makes exploration cheaper and allows extraction to take place at a lower cost. It makes resource use more efficient, permits recycling, and allows lower quality resources to be substituted for higher quality ones.

The effective enhancement of resource quality described by Marx may be illustrated in the impact of a supply shift as diagrammed in figure 14.2. Recalling that the supply line traces production costs, a supply shift to the right, as from Supply 1 to Supply 2 in that figure, represents a general decrease in costs to the resource producing industry. Such a shift would occur, for example, because of a technological breakthrough in resource processing or recovery. Because of the general decrease in costs, locations with resources that were too poor in quality to be exploited under the higher costs represented by Supply 1 can be exploited, with more of the resource being supplied to the market and at a *lower* price.

Differential rent is affected not only by conditions of demand and supply as observed by Ricardo, but also by *location* itself. That contribution to the concept of economic rent was made by J. H. von Thünen, who recognized the importance of transportation cost in the use of agricultural land, and indirectly in the exploitation

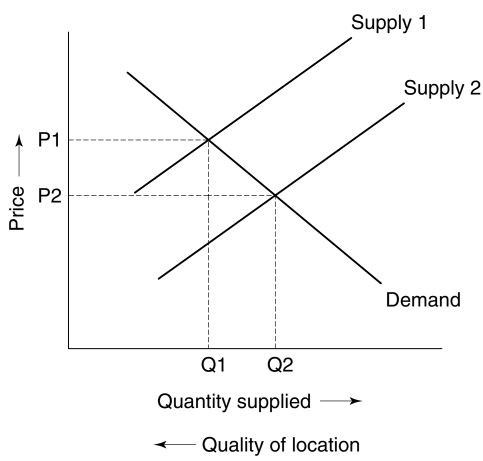

Figure 14.2 A supply shift to the right

of natural resource deposits. The effects of distance on economic rent are illustrated in a *location rent* identity:

$$LR = Q(p - c) - Qtd \tag{14.2}$$

Where LR stands for location rent, Q, p, and c are as defined above in the economic rent identity, t is a transportation charge per unit of output (cents per kilo, for example), and d is distance from the place of resource production or extraction to the place of resource consumption. Location rent is simply economic rent minus a transport charge. If there is no transport charge, if the resource is consumed at its place of production, then economic rent and location rent are the same thing. In reality, however, resources are often consumed well away from their place of production, so transportation costs may play an important role in whether or not a particular mineral deposit or stand of timber becomes a resource.

Indeed, if transportation charges are ignored, then the sequence of resource exploitation predicted by Ricardo and observed by Marx from higher quality to lower quality land and deposits, does not appear to be consistent. Norgaard (1990), for example, has listed a number of seeming historical contradictions: commercial agricultural expansion by European settlers in what is now the United States and the geographical spread of petroleum production in that country are both listed. In both cases, on-site resource quality seems to have little to do with the timing of exploitation. When transport costs are considered, however, the logic of the Ricardian view is borne out by past experience. Some resources "become better than others" simply because they are closer at hand to their possible use. Many petroleum deposits in Appalachia were less productive than those in East Texas, but the distance of the Texan fields from East Coast markets delayed their exploitation.

Ultimately the evaluation of resource quality, like resource recognition, rests on a number of contexts, or conditions. Where minerals are concerned, characteristics such as purity of deposit, depth of deposit, consumer demand, availability of substitutes, and transport cost are necessary contextual factors that enter the calculus of a resource's economic rent. The evaluation is also influenced by technology because each of the factors just listed is responsive to technological change.

Natural Resource Economies

In the production of goods the United States has high value, . . . vast production is made possible by the highly favorable natural conditions prevailing in most of the country. Our forest, mineral, and water resources rank with or above those of any other country . . . (Colby and Foster, 1940, p. 145).

It's not unusual to see countries or regions spoken of favorably as being "blessed with natural resources." In the past, such a blessing was thought particularly to favor a select group of countries, including the United States as indicated in the preceding quotation. Canada, also, is often considered to have advantage with respect to natural resources. One of its best-known scholars, Harold Innis, focused on sequential natural resource recognition and exploitation in explaining the modernization of the Canadian national economy. Innis' *staple theory of development* concerns the interaction of export markets, physical geography, technological change, and institutional preferences for resources sectors as providing the foundation for the pattern of settlement by Europeans across Canada (Hayter and Barnes, 1990).

Staple production, consisting of direct exploitation and initial processing of natural resources, or staples, began with the Atlantic fisheries in the late fifteenth and early sixteenth centuries, and progressed to the interior with the growth of European demand for fur. Expansion into Canada's interior occurred in response to the development of the timber industries of lumber and pulp. A western progression was driven by the agricultural expansion that followed in the prairies during the late nineteenth and early twentieth centuries. Mineral exploitation and petroleum finds led finally to growth in the western prairies and into the lower Rocky Mountains. The transition of intensive resource exploitation from one type and one region to another type in another region resulted from changes in resource technology, demand in foreign markets, and the increasing accessibility of interior Canada led by railroad expansion.

From one perspective, the staple theory of Canadian development tells a story that is positive in terms of the benefits of natural resource supplies and their exploitation in leading to significant growth in a national economy. Average incomes and standards of living are very high in Canada by international standards. An optimistic view of the source of that country's high income and high living standards is that its exports of natural resource financed the growth and diversification of its national economy in a very beneficial way. From another perspective, and one more in line with Innis' thinking (Barnes, 1994), Canadian development has suffered from a reliance on staple production. According to this more pessimistic view, staples production and its emphasis on resource exploitation for external markets has often left Canada at the mercy of a limited number of often foreign multinational corporations and a few domestic interests that actually retard the economic diversification that would lead to greater economic stability.

If the overall success of the Canadian economy (or that of the USA) is a singularly direct result of its past record of natural resource exploitation and trade, then Canada is in a distinct minority of countries. Most countries of the world that rely on exports of primary products are among the world's poorest and face declining or, at best, uncertain incomes from their foreign markets (Porter and Sheppard, 1998, pp. 382–402). Natural resources usually face *declining terms-of-trade* in international markets, meaning their export value tends to decrease against the value of imported manufactured products and services. Often, even rapid expansion of natural resources exploitation and export fail to compensate for decreasing prices in international markets, resulting in a process of *immiserizing growth* – increasing output with decreasing income (Bhagwati, 1958).

Natural resource prices, however, don't always decline. World oil prices increased dramatically, for example in the mid-1970s, and again in the early 1980s because of organized efforts by an important group of oil exporting countries (OPEC) and a revolution in Iran. Such rapid increases in resource prices can lead to economic booms in exporting countries or regions, at least over the short term. Similar booms are experienced with the development of new natural resource fields because of gains in their economic rent brought about by higher prices, lower costs, or improved accessibility. On the surface, such booms appear positive for the national or regional economies they affect, but in reality they often cause significant problems.

One suite of such problems is called the *Dutch disease* because it was first observed in the Netherlands during the aftermath of the oil price increases noted above (Corden, 1984). One part of the Dutch disease is inflation caused by a rapid increase in spending as a response to the rapid increase in natural resource-based wealth. The spending is often targeted at items that are in short supply or not easily produced in the domestic market, and often at services that increase in price but not in quantity or quality. Another problem is the movement of factors from other economic sectors as they chase the wealth in natural resources. In this case, natural resource wealth leads to concentration and specialization in the economy, and not to the eventual diversification indicated in the optimistic version of Canadian staple theory. Currency appreciation is a third problem. As the value of the exporting country's currency gains due to an increase in resource exports, it becomes more difficult to export the country's other products. Again, economic specialization, rather than diversification, is often encouraged by growth in the natural resource sector.

In addition to the Dutch disease issues, Richard Auty (1995) has also identified a *resource curse* that appears to affect countries that become overly dependent upon their natural resource sectors. The curse is that natural resource wealth hinders economic growth in many countries rather than encourages it, as in the Canadian case. A rich natural resource sector has been used in some countries as the foundation for a government policy of attempted self-sufficiency in economic development. Natural resource export earnings are taken for granted and assumed to be able to provide sufficient foreign exchange and government revenue to offset any retaliation by other countries against a policy that uses high tariffs to protect domestic manufacturing from foreign competition. Such protection often leads to noncompetitive manufacturing that, due to its inefficiency, is hard pressed to make any significant contribution to national income. Unfortunately, resource sector exports are unable to sustain a country's government revenue requirements and foreign exchange requirements for very long, but entrenched interests make it very difficult to alter policy toward manufacturing so that it would contribute more to the national economy. The country's resources that were viewed as a consistent source of wealth prove to be a curse that undermines diversification and growth in other sectors.

The resource curse would revert to a blessing if natural resource prices gained consistently in international markets but the record is more of short-term booms and busts over a long-term price trend of decline. The trend of declining prices is ultimately a function of the trend of declining costs as a result of technological advance. Again, refer to figure 14.2, and its illustration of a supply shift to the right that leads to increased consumption at a lower price. As already represented in table 14.1, however, global trends often mask regional ones in the geography of natural resources. The supply shift describes a general decrease in the cost of production that affects a whole industry, but costs at particular places can rise even though costs in general decline.

Man exhausts fish, forest, grassland, and mineral resources, causing fishing villages, lumbering towns, large ranching centers, and mining camps to decline and disappear (Jones and Darkenwald, 1954, p. 5).

The decline, and even disappearance, of settlements with natural resource-based economies seems almost inevitable. Local ore quality declines as the best is used first, raising costs of exploitation, and even so-called renewable resources such as fisheries and forests are often depleted to a point where their products can no longer support a local economy and population. These results are in fact predictable, when the economic rent identity is placed in the context of a capitalist, or market, economy.

Market economies are marked by profit-seeking behavior on the part of producers, whether they are individuals, firms, or corporations. That behavior often extends to attempts at profit maximization within the bounds of the information that the producers possess. In the context of natural resources, that behavior is effectively manifest in ongoing efforts at increasing, if not maximizing, economic rent. Recall from the rent identities of equations (14.1) and (14.2) above that, for any particular resource deposit, economic rent is increased if the price paid for the resource rises or its cost of production and distribution is lowered.

Producer pricing-power in natural resource markets is rare. De Beers, a South African enterprise, has exercised effective price control over diamonds, but more for gem-quality as opposed to industrial-quality stones. OPEC attempted to control international petroleum prices and was successful for a short time, but its pricing-power dissipated fairly quickly for a number of reasons. Most natural resource reserves are too large in volume and too dispersed to have their supply controlled by a single producer or even a small consortium. Because prices are beyond their control, most producers have to rely on reducing their costs in order to increase the economic rent earned by their natural resource deposits.

> ...if production in a particular mine or mineral province declines or ends, it rarely happens because the deposits are physically exhausted, but more probably because new discoveries have reduced extraction costs elsewhere or because substitutes have become available (Houthaker, 1990, p. 441).

It appears that investment at a place gives rise to the decline of its own profitability; low wage labor demands higher pay, for example, or markets become saturated as competitive investment is attracted by the success of initial enterprises. As rent declines in an "old" place, new investment is made in new places. Imbalance in regional economies is the result, as relative success is short-lived. The geographical bounds on the swing of capital decrease as transport and communications costs decline and government exercises less and less control over international flows of non-labor factors of production.

The natural resource sector is marked by a technological treadmill with a geographical expression. The *technological treadmill* refers to the constant development of technology required to maintain rent levels as lower and lower quality resources must be exploited in order to maintain production (Roberts, 1992). Technological advance effectively raises resource quality by lowering costs, but the relative decrease of quality in remaining stocks requires that additional technological advance is soon necessary to sustain economic rent. Increases in reserves are largely the result of technological advance that turns potential supply into a current reserve of the resource.

The geographical expression of the technological treadmill involves the constant expansion of natural resource exploration and extraction. As noted earlier in this chapter, mineral and other natural resource stocks were exploited early on in core economies, where demand for their products was large and transport costs were low. High rates of local exploitation raised costs and lowered rents, inducing technological advance in places but also encouraging the spatial expansion of natural resource exploitation from the core to the periphery. The colonization of Africa focused largely on the exploitation of that continent's natural resources by European powers. The relationship still exists in contemporary linkages such as the long-term US support of Mobutu in Zaire (now Democratic Republic of Congo) because of its interest in securing supplies of that country's cobalt and other *strategic minerals* (minerals necessary in production of certain military equipment).

The reach of natural resources from the core to the periphery was the initial phase of real economic globalization. South American tin and copper (for example, see O' hUallachain and Matthews, 1996) and Middle Eastern oil were the basis of the formation of some of the world's earliest and largest multinational corporations. The recent acceleration of economic globalization resulting from technological advance and the government deregulation of most international flows certainly has not escaped the natural resource sector. Its geographical expansion is occurring especially in frontier, environmentally fragile, regions such as the Arctic and near-Arctic of North America and Asian Russia, and Amazonia in South America (Emel and Bridge, 1995). The accelerated globalization of the natural resource sector has dramatically affected a large number of local economies, already subject to the problems of their rising costs (Flora, 1990).

The decline of local natural resource economies is virtually guaranteed by their very establishment. Local costs of extraction are bound to rise and economic rent is bound to fall as the highest quality resources are exploited first. At the local scale, technological advance is more of a holding action than a method of increasing rent, and its effects usually prove temporary. Local economies are affected by a *resource cycle* of initial growth and ultimate decline (Clapp, 1998). The first part of the cycle consists of exploration, discovery, and an initial economic boom as the resource "becomes" and is brought to market. The second stage is one of profitable operation of local reserves, maintained by increasing capital intensity and applications of technological innovation. The third and final stage is depletion in an economic sense, which occurs when the local resource is replaced, as indicated by Houthaker (above), either by other sources or by a substitute material.

Unfortunately, Clapp (1998) has found that renewable resource-based local economies, such as those relying on forestry or commercial fisheries, are as subject to the resource cycle as mining towns. That is not surprising, however, because processes of resource exploitation do not differentiate between renewable and non-renewable resources.

The decline phase of the resource cycle described by Clapp (1998) is consistent with the decline of local resource quality expected under the Ricardian view of rent, and which occurs with continued exploitation. The decline in quality, revealed by increasing costs of extraction, refining, and even distribution, causes economic rent to decline in a place. As rent declines, geographic relocation of resource exploitation either complements or replaces local technological advance. Employment and income declines in the resource sector lead to a loss of support for other parts of the regional economy in a ripple effect, and the formerly booming natural resource region may fall into severe, long-term decline.

W. R. Freudenburg has written of resource-dependent local economies as being "addictive" (1992). Like a person addicted to a narcotic, such communities fail to recognize the hazard of their activities until it is too late. Even once the problem is recognized, addictive local resource economies try to avoid the withdrawal pains of economic change by various methods of retaining natural resource activities. Most of these methods of retention focus on lowering local costs, and therefore raising the local economic rent, of resource exploitation. Tax reductions and other subsidies are commonly offered by local governments, as is loosening of environmental restrictions. Threatened by loss of employment, local labor often becomes more "productive" by forgoing wage increases, and relaxing work rules and safety standards through subcontracting practices.

Conclusion: Resources, Regional Change, and Sustainability

Natural resource economies are unsustainable in both environmental and economic terms because the practice of rent maximization requires that any resource deposit be exploited until it no longer holds any economic reserves. There is, in fact, a so-called *optimal rate of depletion* of a natural resource that is determined by the rate of interest (Barbier, 1989, pp. 62–74). High interest rates warrant more rapid rates of depletion, so that greater income may be earned in non-resource markets, while low rates of interest allow less rapid rates.

In conjunction with seemingly inevitable economic decline, most resource-dependent economies are faced with environmental degradation. Again, rent maximization in competitive markets is most likely to be accomplished by cutting costs of production. Preserving environmental quality, however, by containing acidic runoff from mining operations, for example, or limiting soil erosion in lumbering, is expensive. Often such costs are viewed as unnecessary to actual production, and so are ignored by natural resource enterprises. Typically, government must either impose regulations forcing polluting enterprises to pay environmental mitigation costs ("costly regulations" is a commonly used phrase) or society must pay the financial costs and, too often, the health costs of the environmental degradation.

Sustainability in both economic and environmental senses is achievable, but it requires a change from traditional thinking about resources that is not always easy to make (Reed, 1995). The conventional view of natural resources is that they have value only when employed as factors of production. That view has led to calculations of "optimal" rates of depletion. In addition, that view has led to the implicit recognition of resource depletion as a contribution to national wealth: resource consumption contributes to gross domestic product in national accounts, while conservation does not (Steer and Lutz, 1993). At the local level, resources are viewed in the same way. Jobs and income are generated when natural resources are exploited as factors of production: unemployment and poverty result from their preservation (Power, 1996).

There is, however, a change occurring in the way natural resources are evaluated. Increasingly, recognition of their locally finite nature is resulting in a conscious effort on the part of some producers and many affected communities to limit technological applications to local resource extraction. Technological and capital limitations are being imposed in the Northern Forest of New England, for example, by so-called green producers who have stopped clear-cutting lumber in favor of lower impact selective harvests (Brown, 1998). The same type of limitations are being self-imposed in developing regions, as well, in the interest of providing both economic and environmental security (Litvin, 1998). In some circumstances, mineral exploitation is being forgone in recognition of the net costs of environmental, cultural, and economic despoliation that results from the natural resource cycle (Barre, 1998).

Natural resources are, of course, necessary factors of production and can't be eliminated from use entirely, nor can their contribution to local economies easily be cast aside. Sustainability, however, requires that resource dependency – the development of the resource addiction – be avoided. Such dependency can be avoided through economic diversification that broadens a regional (from local through national scale) economy's base from a narrow focus on resource exploitation to the employment of available resources as inputs to manufacturing and services. The benefits of economic diversification are well known at the national scale, but they exist at regional and local scales as well. By mitigating the boom and bust of the resource cycle, economic diversification can provide a sustainable base of employment and income. By providing economic alternatives, diversification also can enhance environmental sustainability by reducing the exploitation pressure of local resource dependency.

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