U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Policy – A Factor Shaping Minerals Supply and Demand

Open File Report 02-418

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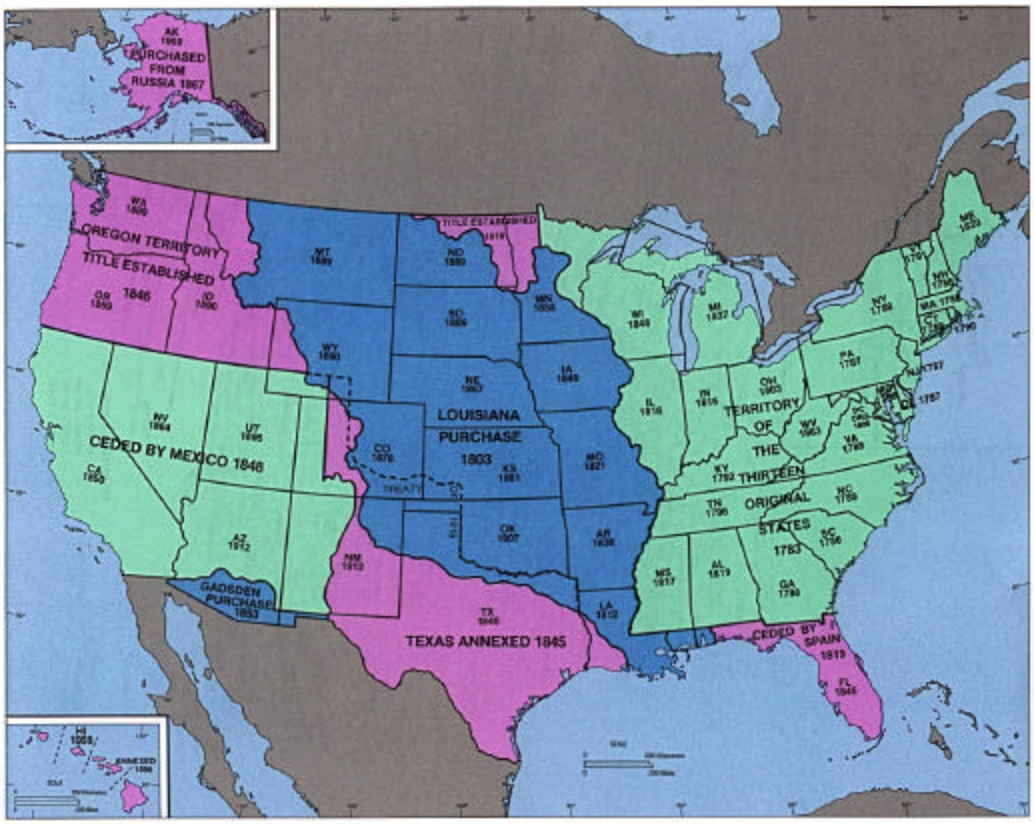

Map photo credit: University of Texas, 2001

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5.1 ABSTRACT

Valuable insights about the future availability of minerals for the U.S. economy can be gained from a study of the history of U.S. mineral development. From the beginning, first as corporate ventures, next as colonies, then as States united, American governments have pursued policies that had the effect to encourage development of mineral and other resources.

During the frontier period, 1781–1890, all levels of government in the United States spent public money for infrastructure development (canals, forts, ports, railroads, roads, and other), and the Federal government was particularly active in land acquisition, land surveys, and resource title transfer to private interests. These activities were effective support for the development of the nation's mineral resources. This was a period of rapid growth, wealth building, and substantial land disturbance.

During the post-frontier period, 1891–present, the consequences of resource development helped to move values for ecology and culture to the forefront of public policy, making them more competitive with development values. To date, American history's lesson has been that policy is very important with regard to where and how minerals are placed into the service of human needs. This is also the history of global mining, as mining capital has moved to friendly policy environments. Although policy can create regional dislocations of mining, it has had little effect on the long-term global availability of minerals at continuously decreasing prices.

5.2 INTRODUCTION TO THE STUDY

The possibility of future mineral scarcity is an important concern of environmental activists, those desiring to limit population growth, and those concerned with wealth distribution between industrialized and developing countries. Through the years, observers from Thomas Malthus (1798) to the 1972 Club of Rome report, (Meadows and others, 1972), for example**,** predicted exhaustion of resources at various dates, most of which have come and gone without the dire consequences of societal collapse they envisioned.

The static model from which these predictions came continues to inform many who choose to believe that mineral production cannot meet the material aspirations of a rapidly growing world population if consumption (one component of which is resource capitalization, which is often overlooked by these analysts) of some resources continues to increase. The perception of future scarcity, for example, motivated the Factor Ten Club, a group of resource economists, to issue the Carnoules Declaration in 1994 and 1995. The Declaration called for a swift 10-fold increase in material efficiency among industrialized countries to free materials for people in developing countries (Factor 10 Club, 1995).

The concerns of future scarcity may in part be caused by misinterpretation and (or) the misuse of published mineral reserve estimates for non-fuel mineral commodities. A reserve is that part of an in-place demonstrated resource that can be economically extracted or produced at the time of estimation (U.S. Bureau of Mines and U.S. Geological Survey, 1980). Some misinterpret the term “reserve” as an estimate of all-that-is-left.

Mineral supply starts with the physical existence of materials, and can be no greater than its occurrence in the Earth's crust. The amount of material actually supplied to society (economic supply) is that which is called forth by demand (willingness-to-pay), as moderated by the cost of production, which is influenced by physical realities, technology, politics, and social concerns.

Physical Factors Affecting Mineral Supply

1. **Geographic distribution of concentrations of potential ore minerals.**
2. **Depth of these concentrations.**
3. **Grain size of the minerals.**
4. **Mineralogy (sulfides versus oxides).**
5. **Grade (percentage of desired elements in the ore).**
6. **Tonnages of the concentrations.**

Source: DeYoung and Singer, 1981.

In fact, many of the minerals that the Earth's population demands exist in nearly inexhaustible amounts. Additionally, there is an enormous stock of resources in materials in-use (machinery, buildings, and roads) and in unutilized waste (landfills). There is, however, a growing understanding that physical scarcity is not the only, or even the most, important issue. Industrial activities extract and transform resources into products people use. In many cases, these activities come with direct or accumulative environmental consequences that can pose serious threats to ecosystems and human health. Thus, the important issue of scarcity may be the capacity of Earth's geologic, hydrologic, and atmospheric systems to assimilate the wastes (Meadows and others, 1972).

This series, "Scarcity in the 21st Century", addresses resource constraints and opportunities, and the effects of their interactions on resource supply. Assessing potential supply requires a whole systems approach, both in physical terms by looking at the flows of materials through the economy, and in human terms by integrating the interactive domains of economics, environment, policy, technology, and societal values.

In 1929, D.F. Hewett, of the United States Geological Survey (USGS), reflecting on the effects of war on metal production, identified four factors he deemed most important in influencing metal production (Hewett, 1929).

1. Geology

> "First, there are the geological factors, which are concerned with the minerals present; their number and kind, which determine whether the problem of recovery is simple or complex; the degree of their concentration or dissemination; their border relations; the shape and extent of the recognizable masses."

2. Technology

> "Second, there are the technical factors of mining, treatment and refining. A review of these leaves a vivid impression of the labor involved in their improvement but they necessarily yield cumulative benefits."

3. Economics

"The third group of factors that affects rates of production are economic, and among these factors cost and selling price are outstanding... Since 1800 the trend of prices for the common metals, measured not only by monetary units but by the cost in human effort, has been almost steadily downward…"

4. Politics

"The fourth group of factors that affect metal-production curves are political or lie between politics and economics."

The four factors do not operate separately, but rather as parts of an integrated system, which also includes social constraints and drivers such as environmental issues and the structure of the mining industry.

"Scarcity in the 21st Century" is composed of six chapters to be published in a series of USGS Open File Reports and then compiled as a USGS Circular.

Chapter 1: "The Supply of Materials" examines the physical supply of minerals on the planet, in the ground and products-in-use, waste streams, and waste deposits (landfills). Current and future potential for recycling of products-in-use and landfill materials are examined.

Chapter 2: “Economic Drivers of Mineral Supply” explores price, investment, costs, and productivity, and their relevance to supply.

Chapter 3: “Technological Advancements – A Factor in Increasing Resource Use” investigates the impact of technological change on mineral discovery, extraction, processing, use and substitution.

Chapter 4: “Social Constraints and Encouragement to Mineral Supply” addresses social realities that affect mineral supply, nationally and globally, and the socio-cultural trends that promise to have an impact on future supplies.

Chapter 5: “Policy – A Factor Determining the Parameters of Minerals Supply and Demand” examines the effect of government policies that either promote or restrain mineral development, some of which include: access, title, regulation, rent, royalty, and tax fees, and direct and indirect subsidies. This volume also discusses the affects of corporate policies on mineral supply.

Chapter 6: “Overview of Minerals Supply” presents an overall view of these parameters of supply to show their synergy in supply and ultimately production.

Each chapter contains ample reference to historical information about one or more commodities to illustrate the concepts.

5.3 INTRODUCTION TO THIS VOLUME

Two ways to approach a discussion about the relationship of policy and the minerals industry are: 1. To observe how policies of all kinds impact the minerals industry; and 2. To look at government attempts to shape specific minerals policies. This report will take the first approach, laying out chronologically the important policies that have helped to shape the industry as it is. Throughout the chronological discussion, information about minerals policy, per se, will be fitted as appropriate.

Between 1790 and 1890, the U.S. population increased from 3.9 million to 62.1 million, a compound annual growth rate of 2.81 percent (University of Virginia, 2000§[1]), and 79 percent of the present U.S. land area was acquired (The Learning Network, Inc., 1990§). It was a century of wealth building, land acquisition and privatization, settlement, and development. After the frontier was declared closed, in 1890 by the Census Bureau, the population grew at a compound annual growth rate of 1.38 percent to 281.4 million at the 2000 Census (University of Virginia, 2000§). While economic development still carries considerable weight in policymaking, other values concerning avoidance of adverse consequences of development have become important, placing obstacles to development. Sustainable development incorporates more goals (socio-cultural, and environmental) into production decisionmaking (Otto, and others, 2000).

Markets exist, independent of laws that legitimize, tax or subsidize them, or control access to them. For example, between 1849 and 1866, miners, driven by the market for

[1] The § indicates that the source is an Internet site, the citation for which is located in the sub-section "Internet References Cited", within the section "References".

minerals, squatted on the public lands. The General Mining Act of 1872, and its antecedents, the Lode Law of 1866, and the Placer Act of 1870, simply codified what the miners, their bankers, and local governments had worked out for themselves in the absence of a workable national minerals policy prior to 1866 (Sokoloski and Deery, 1997).

In a market economy, laws that tax, regulate, subsidize, and control access to minerals, have the effect of modifying commodity production costs, and thereby, project cash flow. Cash flow changes affect project returns, and thereby alter producer investment decisions. For example, percentage depletion allowances increase cash flow, whereas the cost to collect pollutants decreases cash flow. Project cash flow is the item that is discounted (for risk) in the choice of alternate investments (Stermole and Stermole, 1990, p. 6-11).

For the past 100 years, mineral commodity production has trended upwards, and mineral commodity prices have trended downward (Sullivan, and others, 2000). Mineral production firms have taken steps to redistribute mineral commodity production to areas on the globe where, all else being equal, there is less impact to their cost structures from laws and regulations, causing, at least in part, local production dislocations. (See risk discussion, beginning on page 52.) What follows is a review of the impacts of U.S. policy, after it works its way through our economic system, on the U.S. minerals industry, and a look at the chronological development of U.S. mineral policy.

5.4 CHRONOLOGICAL HISTORY OF POLICIES AFFECTING THE MINERALS ECONOMY OF THE UNITED STATES

Throughout U.S. history, there have been many laws passed and regulations promulgated affecting mineral supply. These include infrastructure development, public lands acquisition and disposal, and minerals development *per se.* English-American history began when the English economy was run on the philosophy of merchantilism, with royal grants of land to corporations (Plymouth Company, Virginia Company, Massachusetts Bay Company), for the purpose of establishing trading monopolies. In characteristic merchantilistic fashion, The Iron Act of 1750 passed by the English Parliament encouraged the export of pig and iron bar from the colonies to England. It forbade erection of new blast furnaces or other downstream iron working facilities in the colonies (R.E. Deery, U.S. Bureau of Land Management, written commun., 2002).

Land speculation was a driving economic force in the merchantilistic colonial period, and it is not surprising that the United States continued the policy well into the post-colonial period (R.E. Deery, U.S. Bureau of Land Management, written commun., 2002). This paper covers the post-colonial period, which can be further subdivided into two sub-periods: The first, the frontier period, 1781 (Ratification of the Articles of Confederation and perpetual Union) to about 1890; the second, the post-frontier period, 1891 to the present, with special emphasis after 1990 when "sustainable development" became, for many, the context within which global minerals supply decisions should conform.

Frontier Period (1781–1890)

For the years 1781–1890, it can be said that the United States was on a mission, which in the 1840s acquired the name Manifest Destiny (University of Texas, 2001§). While the concept of an American mission is a highly charged topic, there remain certain features of the period that can be discussed objectively, including: land acquisition, publicly financed land surveys and exploration, public land privatization, infrastructure subsidies, and bi-metallic monetary policy.

MANIFEST DESTINY

"Manifest Destiny" was a term first used by Jane McManus Storm Cazneau, 1807–78, to describe the American mission. She was an essayist for the United States Magazine and Democratic Review, published in New York, and an activist for political causes.

Source: University of Texas, 2001§

Land Acquisition:

The Authority for the United States to acquire and dispose of land is found in the United States Constitution, Article 4, Section 3, Clause 2: "The Congress shall have Power to dispose of and make all needful Rules and Regulations respecting the Territory or other property belonging to the United States; and nothing in this constitution shall be so construed as to Prejudice any Claims of the United States, or of any particular State" (U.S. House of Representatives, 2002§).

From its inception, it took the United States only 117 years (1781–1898) to acquire, by one means or another (See Table 1), the right to govern the land area comprising the current 50 States.

Table 1. Land acquisitions that grew 13 original United States to 50 United States.

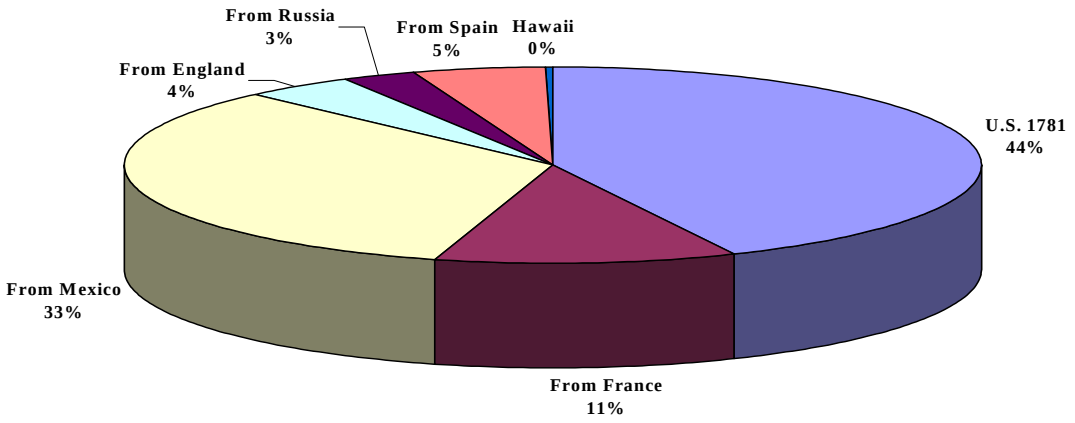
Land Acquisition	Date Acquired	From	States derived from acquired land:
Treaty of Paris	1783	Great Britain	Alabama (95%), Illinois, Indiana, Kentucky, Maine, Michigan, Minnesota (33%), Mississippi (95%), Ohio, Tennessee, and Wisconsin
Louisiana Purchase	1803	France	Arkansas, Colorado (40%), Iowa, Kansas (80%), Louisiana, Minnesota (67%), Missouri, Montana (90%), Nebraska, North Dakota, Oklahoma (85%), South Dakota, and Wyoming (60%)
Florida Purchase	1819	Spain	Alabama (5%), Florida, and Mississippi (5%)
Texas Accession	1845	Republic of Texas (Mexico)	Colorado (30%), Kansas (20%), New Mexico (65%), Oklahoma (15%), Texas, and Wyoming (5%)
Webster-Ashburton Treaty	1846	Great Britain	Idaho, Montana (10%), Oregon, Washington, and Wyoming (15%)
Guadalupe-Hildago Treaty	1848	Mexico	Arizona (75%), California, Colorado (30%), Nevada, New Mexico (33%), Utah, and Wyoming (20%)
Gadsden Purchase	1853	Mexico	Arizona (25%), and New Mexico (2%)
Alaska Purchase	1867	Russia	Alaska
Hawaii Accession	1898	Republic of Hawaii	Hawaii

Compiled from Gannett, 1900.
The 13 original colonies, Vermont (from New York), and West Virginia (from Virginia) are excluded.
Numbers in parentheses represent the author's estimate of percent of the State's territory associated with the subject acquisition.

Figure 1 represents the author's estimate of the percentage of 1999 non-fuel (metals and non-metals, including cement, sand, gravel, crushed stone, and other industrial minerals) mineral production value that each land acquisition contributed to the total (Data extracted from: Smith, 2001§, and Gannett, 1900). The United States was well endowed with mineral potential in 1781, when its western boundary was the Mississippi River. The 19th century territorial acquisitions, which eventually became States, account for more than half of the

non-fuel mineral values produced in the U.S. in 1999. Excluding the land associated with the Treaty of Paris, the largest share of 1999 non-fuel mineral production value came from land acquired from Mexico (Guadalupe-Hildago, Texas Accession, and Gadsden Purchase).

Figure 1. Percentage of U.S. 1999 non-fuel mineral production value derived from territories acquired by the United States.



Graphic derived from information extracted from Smith 2000§, and Gannett 1900.

While the United States pursued a policy of adding land and the attendant resources to its control, it also pursued policies of support for exploration, surveys to categorize the new lands, policies to transfer ownership of the public lands to private interests, and infrastructure construction — canals, forts, highways, and railroads to move and protect goods and people.

Exploration and Surveys:

With the Louisiana Purchase in 1803, President Thomas Jefferson wanted to see what he had obtained for $15,000,000. He sent his trusted advisor, Meriwether Lewis, and his associate William Clark to explore the Missouri River and its major tributaries. They were charged to study climate, plant and animal life, and to meet Indian tribes and study their culture (Anderson, undated,§). In 1807, the Federal Government commissioned the Coastal Survey, which was commissioned to chart coastal waters and navigation aids for commercial interests (Rabbitt, 1989§).

FEATHERSTONAUGH

In 1832, George W. Featherstonaugh, an English-born geologist, wrote a letter to Secretary of War Lewis Cass advocating the expenditure of government funds for systematic surveys to obtain knowledge of the Nation's mineral resource endowment.

Source: Barsotti and others, 1998.

Government exploration and land surveys had an indirect effect on mineral development, providing essential information to support private prospectors as well as to plan for secure infrastructure development and land. Figure 2 is a representation of a geologic map from the Amos Eaton survey of 1830.

Figure 2. Amos Eaton's geologic map of New York State (1830).

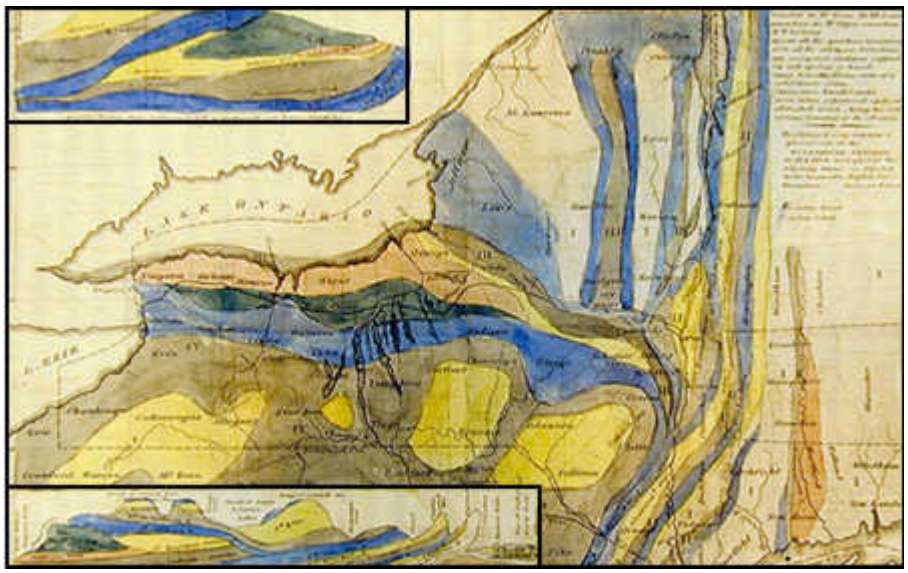


Photo credit: Aldrich, 2002§.

Table 2 lists other important land surveys of the 19th Century. Some of these were directed to search for specific minerals, including gold.

Table 2. Selected 19th Century Government-funded land surveys.

Name/Authority	Year	Purpose
Amos Eaton/New York	1820	Albany County, NY, for agriculture
Amos Eaton/New York	1821	Rensselaer County, NY, for agriculture
Amos Eaton/New York	1823	Districts adjoining Erie Canal, for agriculture
D. Olmstead/North Carolina	1823	State, for agriculture and gold
Army Corps of Engineers	1824	Public canals and roads
Topographical Bureau, U.S. Army	1834	Geophysical structure, mineral resources and products of the public lands
U.S. Exploring Expedition	1836	Explore U.S. territory
Corps of Topographical Engineers	1838	Map the continent, a project that continues to date
Fremont Expeditions	1842–46	Three expeditions through the American northwest (English control), and the American west (Spanish control).
Railroad Exploration	1853	To find most practical rail route from Mississippi River to west coast.
Clarence King U.S. Corps of Engineers	1867	Survey the 40th Parallel for rail possibilities
John Wesley Powell	1869	Explore Green and Colorado rivers
George Wheeler	1869	North-South routes through Nevada
Ferdinand V. Hayden	1871	Survey Nebraska, Colorado, and Wyoming
U.S. Geological Survey	1879	Established as permanent agency for mineral, water, and survey work, including mapping

Compiled from: Rabbitt, 1989§.

Public Land Privatization:

While land acquisition from European colonial powers and their successors provided the political control over territory, settlement and utilization of the new lands required further treaty and legislative action to deal with the obstacle of aboriginal rights. Table 3 lists some of the important land privatization legislation of the 18th and 19th centuries.

Table 3. Important land privatization legislation of the 18th and 19th centuries.

Legislation	Year	Public Purpose
Land Ordinance	1785	Provided the method of surveying and a plan for disposal of the lands, but also reserved one-third part of all gold, silver, lead, and copper mines to be sold or otherwise disposed of, as Congress shall thereafter direct[1].
Indian Removal Act	1830	Removed the five "civilized" tribes from their lands east of the Mississippi River to Indian Territory (Oklahoma), opening the American South to settlement by colonists[2].
Homestead Act	1862	Allowed anyone to file for a quarter section (65 hectares) of free land subject to certain performance restrictions[3].
Morrill Act	1862	Gave every State 12,000 hectares of public land for every member of its congressional delegation. The States were to sell the land, and use the proceeds to develop colleges of engineering, agriculture and military sciences[4].
General Mining Act	1872	Allows an individual to locate (claim) and patent (take title to) metallic mineral deposits on public lands, subject to certain performance requirements.
Black Hills Settlement Act	1877	Arguably settled, by title cession, a controversy between gold miners and the Sioux Indian Nation about sovereignty over the Black Hills of South Dakota[6,7]. The Indian sovereignty claim was founded on the Treaty of Laramie (1868)[8].
Dawes Severalty Act	1887	Permitted individual Indians to own land privately. Resulted in transfers of large parts of Indian territory to Euro-American settlers[9].

1. Indiana Historical Bureau, undated§.
2. Studyworld, 2000§.
3. Pence, undated§.
4. U.S. Department of State, 2001§.
5. Feriancek, 2001a§.
6. First Nations Homepage, undated§.
7. Bucko, 2000§.
8. Pisarowicz, 2001§.
9. Grand-Jean, 2001§.

U.S. public land policy, driven by the need to finance Government and pay off the Revolutionary War debt, predates the ratification of the U.S. Constitution. Under the Articles of Confederation and perpetual Union, 1785–89, the Congress passed the Land Ordinance of 1785, which applied to the Northwest Territories, eventually the States of Ohio, Indiana, Illinois, Wisconsin, and part of Minnesota, the 259-hectare square township system, which

currently is used throughout the entire American west. The Land Ordinance provided a school lands program, which dedicated lands in each township to support public schools and the right of education for all people. Leases of mineral rights on these public lands were to provide revenue to the government, some of which was dedicated to the schools. Furthermore, one third part of all gold, silver, lead and copper mines sold to the public would be reserved to the United States out of every township (Western States Land Commissioners Association, undated§).

The nature of the Land Ordinance of 1785 is illustrative of the influence of English Common Law on early policy. Under the Common Law, mineral title was joined to the surface estate for all but the royal metals, gold and silver. In England, holding land title required the holder to do service to the King, usually in the form of making annual payments called quitrents. Thus the land was held in "fee-simple". Such arrangements were part of colonial land grants, the holders of which wanted quitrents from the colonists. The Land Ordinance, in keeping with this tradition, and the form of early colonial charters, sought its "quitrents" in the form of a one third interest in the mines, and added lead and copper to the "royal" metals (Sokoloski and Deery, 1997).

Some of the earliest instances of a developing minerals policy are associated with the acquisition of these lands. In 1796, Congress directed surveyors note all mines, salt licks, salt springs and mill seats, and a mile around them for reservation to the Government for future disposal. Similar reservations were published in Ohio in 1803, and Indiana in 1804. In 1807, two laws were passed, both reserving new settlements on lands holding lead resources, which the Government intended to lease for revenue purposes (Siskiyou County Farm Bureau, undated§).

LEAD MINE EXPERIENCE

The Federal leasing system for lead mines, which was based on legislation passed in 1807, was bitterly contested by lead miners complaining that lease durations were too short, the land grants were too small, and the method of paying royalties were too difficult. Miners complained that amateurs were obtaining leases, intruders without leases were proliferating, and land reservations for mining were incompetent. The cost of the system outweighed the revenues to the government, and the mines were ultimately privatized. This negative experience informed the development of the privatizing aspects of the General Mining Law of 1872, and its precursor, the Lode Law of 1866.

Source: Hazen and Hazen, 1985.

The Indian Removal Act of 1830 made land available for Euro-American settlement, mineral exploration and development. The southeastern tribes were forcibly relocated to Indian Territory (Oklahoma) (Studyworld, 2000§). One of the major reasons for the relocation was the discovery of gold on Indian land. Gold prospectors were so anxious to work rich deposits on Cherokee land that they increased the already existing pressures on the government to displace the Indians (Hazen and Hazen, 1985).

The Homestead and Morrill Acts are important examples of land privatization, but had little influence on mineral supply. However, it is important to note that these two Acts

granted the entryman full fee title, thus putting all of the mineral rights into the hands of the private citizen with no reservation to the Federal government. This created a large reservoir of private interests in minerals (R.E. Deery, U.S. Bureau of Land Management, written commun., 2002).

The General Mining Act of 1872, which effects hard-rock mineral privatization, is important with respect to supply. The Act combined features of the Lode Law of 1866, and the Placer Act of 1870. The Act was passed to secure the substantial financial outlays invested in Nevada's Comstock Lode. The Lode Law and the Placer Act codified what miners had evolved among themselves, their financial backers, and local governments as appropriate behavior regarding conflicting claims. However, claims conflicts persisted until passage of the Mining Law of 1872, which regulated the procedures for staking claims on Federal lands, working claims, and obtaining title (privatizing) to the minerals. Over 350 years of successful experience under Spanish and Mexican mining codes, as opposed to the bad experience with lead leasing in the Upper Mississippi Valley, informed the development of mining law in the U.S. west, and ultimately

LINCOLN'S MINING SENTIMENTS

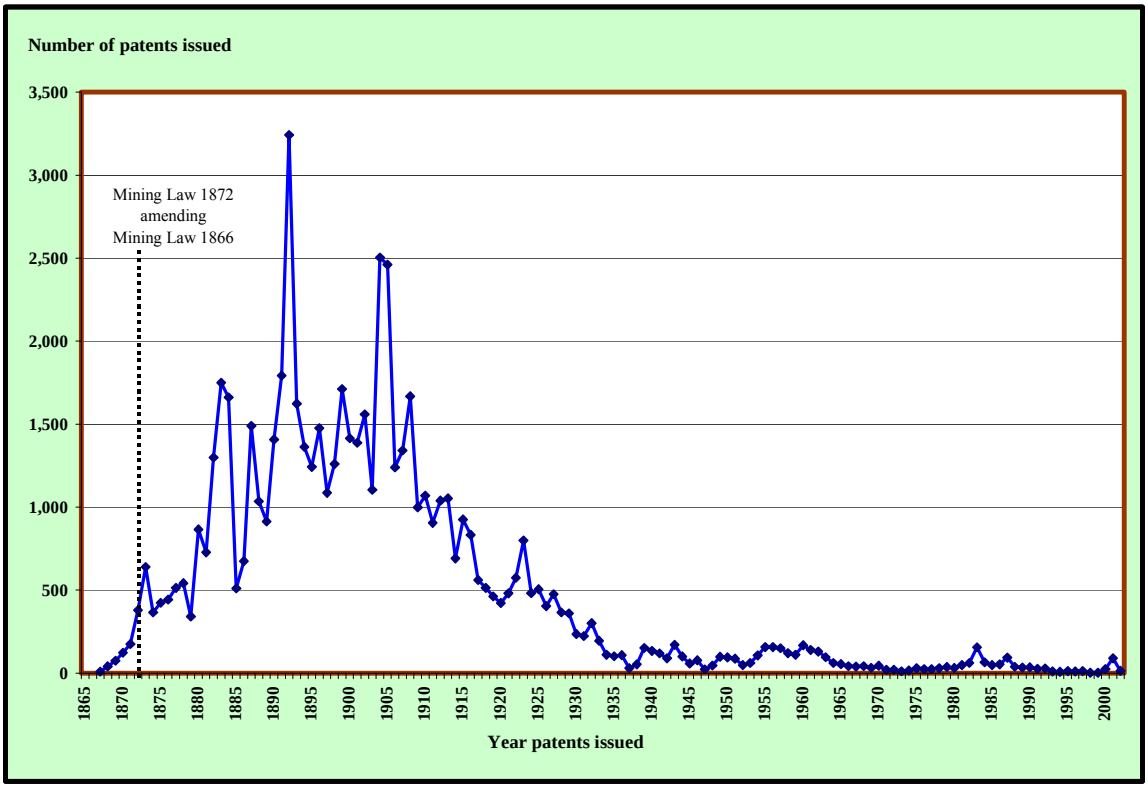
"I have very large ideas of the mineral wealth of our Nation. It abounds all over the western country, from the Rocky Mountains to the Pacific, and its development has scarcely commenced. Immigration, which even the war has not stopped, will land upon our shores hundreds of thousands more per year from overcrowded Europe. I intend to point them to the gold and silver that waits for them in the West. Tell the miners from me, that I shall promote their interests to the utmost of ability; because their prosperity is the prosperity of the Nation, and we shall prove in a very few years that we are indeed the treasury of the world."

Abraham Lincoln, April 14, 1865
Source: Committee on Resources, 2001§

became the basis for the private mining features of the General Mining Act of 1872 (Sokoloski and Deery, 1997).

The Act permits self-initiated access to public lands for the purpose of locating and obtaining title to minerals, and establishes a uniform set of rules to determine rights and ownership of discovered minerals. Possessory title is created by the act of discovering the valuable mineral deposit. A patent, if desired by the mining claimant provides a secure property right, which is important to lenders and investors seeking collateral for loans. If one pays a $100 per year holding fee, pending favorable economic conditions for mining, one may mine whenever appropriate, and later patent (obtain title to) the resource for a very nominal cost – exclusive of the costs to produce the property. The costs to produce the property are much greater than the nominal payment, creating local investments, jobs, and tax revenues. The General Mining Act of 1872 recognized a common belief of that day, namely that those who take the high risks associated with finding minerals should be rewarded with a property right to them (R.E. Deery, U.S. Bureau of Land Management, written commun., 2002). Figure 3 shows the patent activity under the 1872 Act to the present, with the bulk of hard rock patent activity having taken place prior to 1935.

Figure 3. Patents issued under the General Mining Act of 1872.



Source: R.E. Deery, U.S. Bureau of Land Management, written commun., 2002.
Data for years 1867 through 1873 is claims patented, not patents.

In the context of the frontier period, the General Mining Act of 1872 was an incentive to get the population to spread west (Krent and others, 1999§), as well as a way to organize the chaotic mining industry of the day (R.E. Deery, U.S. Bureau of Land Management, written commun., 2002). Presently, the Act is under fire by those seeking to prevent damage to the environment, and their strategies include calls for repeal, or the imposition of royalties to make claim patenting much more costly (Feriancek, 2000a§). The 1872 mining law originally applied to the majority of locatable minerals on Federal lands. In 1920, oil, natural

gas, coal, and certain other bedded, defense related minerals were removed from the location and patent regimen and placed under a leasing system, discussed below.

The Black Hills Settlement Act was a direct response to the discovery of gold in the Black Hills of South Dakota. The Sioux tribe had been given sovereignty over the Black Hills by the 1868 Treaty of Laramie, which concluded the Indian wars in the region. When gold was discovered on the Indian land, the miners simply moved in, setting up a confrontation with the Indians. The Black Hills Settlement Act was passed to end the confrontation. However, the number of Indian signatures acquired to validate the passage of the Black Hills Settlement Act fell short of the number required by the Treaty of Laramie for a legal cession of Indian land title. The Supreme Court adjudicated the issue, and awarded a monetary settlement for a "taking" to the Sioux Tribe. However, the Sioux to this day have not accepted the settlement, and continue to claim sovereignty over the Black Hills (First Nations Homepage, undated,). The Homestake Mine, located in Lead, South Dakota, has operated for over 123 years and produced over 1.2 million kilograms of gold. Operations consist of a 2,400-meter-deep underground mine, and associated mill. Homestake is closing the underground mine (Homestake, 2002§).

The Dawes Severalty Act was passed to help the Indians to learn about the benefits of private land ownership so that they would become more integrated with the settler population. The good intentions were lost, according to critics, when the private Indian titles established by the Act were transferred through ordinary market real estate transactions, and large portions of Indian land fell into the hands of settlers and mining interests (Grand-Jean,

undated§). In general, Indian cultures were less favorably inclined to mining than the Euro-centric settler culture. Some have traced these differences to theological bedrock, but that is beyond the scope of this study.

Infrastructure subsidization:

After acquiring, surveying, and privatizing mineral lands, government policy to subsidize infrastructure development was the next most important factor in mineral development, both in the frontier period, and in the post-frontier period. Local, State, and the Federal government subsidized infrastructure (canals, forts, railroads, and roads) development. These provided security and routes to move goods and personnel throughout the country. Canals and railroads are direct participants in mineral development, and are discussed below.

Canals:

During the period 1820–50, canal building was the major part of infrastructure development in the United States. The most important of the early canals built with government tax receipts was the 40-ft wide Erie Canal, which was initiated in 1818 for

OHIO CANAL MINERAL TRADE (1833)

(Canal trade measured at Cleveland)

Bushels of coal:	**49,131**
Pounds of pig iron:	**2,147,822**
Barrels of salt:	**28,447**
Pounds of gypsum:	**1,183,197**

Source: Cleveland Memory, 1999§

$7,000,000 (a little less than half the price of the Louisiana Purchase), and completed in 1825, covering a distance of 584 kilometers (km) (New York State Canal Corporation, 2001§).

Between 1825 and 1848, over 1400 km of canals were built in Ohio by State and private enterprise (Adkins, 1997§). Final costs for the Ohio and Erie, and Miami and Erie Canals totaled $16,000,000 for construction and $25,000,000 for interest on the loans, which almost bankrupted the State (Adkins, 1997§).

The Pennsylvania anthracite mines were located more than 95 kilometers from Philadelphia, the major port. Overland routes, in the 1830s, were virtually impassable during wet periods, and the local rivers were not navigable prior to 1820. Over the period 1820 to 1850, a network of canals, and later railroads, linked all of the Pennsylvania anthracite districts to the major cities and ports on the Atlantic coast (Hazen and Hazen, 1985). Table 4 is a listing of the important State-financed, mineral-related canals.

Table 4. Mineral-related canals.

Canal Designation	Completed	Where and/or What
Conewego Canal	1797	Susquehanna River, local access to anthracite coal[1,2].
Susquehanna Canal	1802	Susquehanna River, Chesapeake Bay access to anthracite coal[1,2].
Schuylkill Navigation	1825	Schuylkill River, opens anthracite to Philadelphia[1,2].
Chesapeake and Ohio Canal	1828	Potomac River, Maryland coal to Washington, D.C.[1,3].
Delaware and Hudson Canal	1828	Anthracite, Pittston, Pennsylvania to Kingston, New York[1]
Lehigh Navigation	1829	Lehigh River, anthracite route to Philadelphia[1,2].
Morris Canal	1831	Direct route for transporting anthracite from Pennsylvania to Newark Bay, New Jersey[1]
Susquehanna North Branch	1831	Opens coal fields of Nanticoke, Pennsylvania[1,2].
Delaware and Raritan	1831	Competition for Morris Canal[1].
Pennsylvania Main Line Canal	1834	Connected Pittsburgh with Philadelphia, with intricate incline plane portage over Allegheny Mountains between Johnstown and Hollidaysburg Pennsylvania. Market for iron and agricultural products[1,2]
Greenville Canal	1844	Shenango River, opened Pittsburgh to Lake Erie, for transport of iron, coal, and limestone[1,2,4].
Soo Locks	1855	Connected Lake Superior to Lake Huron, opening the Michigan and Minnesota iron and copper ranges[1,5].

1. Minor, 1996§.
2. Pennsylvania Historical Museum Commission, undated§.
3. U.S. National Park Service, 2001b§.
4. Greenville Historical Commission, undated§.
5. U.S. Army Corps of Engineers, Detroit District, undated§.

By 1860, there were over 6,400 km of canals in operation in the United States (National Railroad Museum, 1999§). The largest tonnage items transported were agricultural. However, Pennsylvania coal was essential to fuel the growing steam engine sector of industry, provide coke for hundreds of rural ironmaking furnaces, and for space heating.

The Soo Locks were built when Congress passed an act in 1852 granting 304,000 hectares of public land (the subsidy) to the State of Michigan as compensation to the company that would build it (U.S. Army Corps of Engineers, undated§). When the Soo Locks, in combination with local railroads to carry ore to Lake Superior ports, opened, the products of the rich copper and iron deposits in Michigan and Minnesota became available. By 1898, large- scale iron production from these regions wiped out the New Jersey iron properties (R.E. Deery, U.S. Bureau of Land Management, written commun., 2002). Figure 4 shows the Soo Locks as they appear presently.

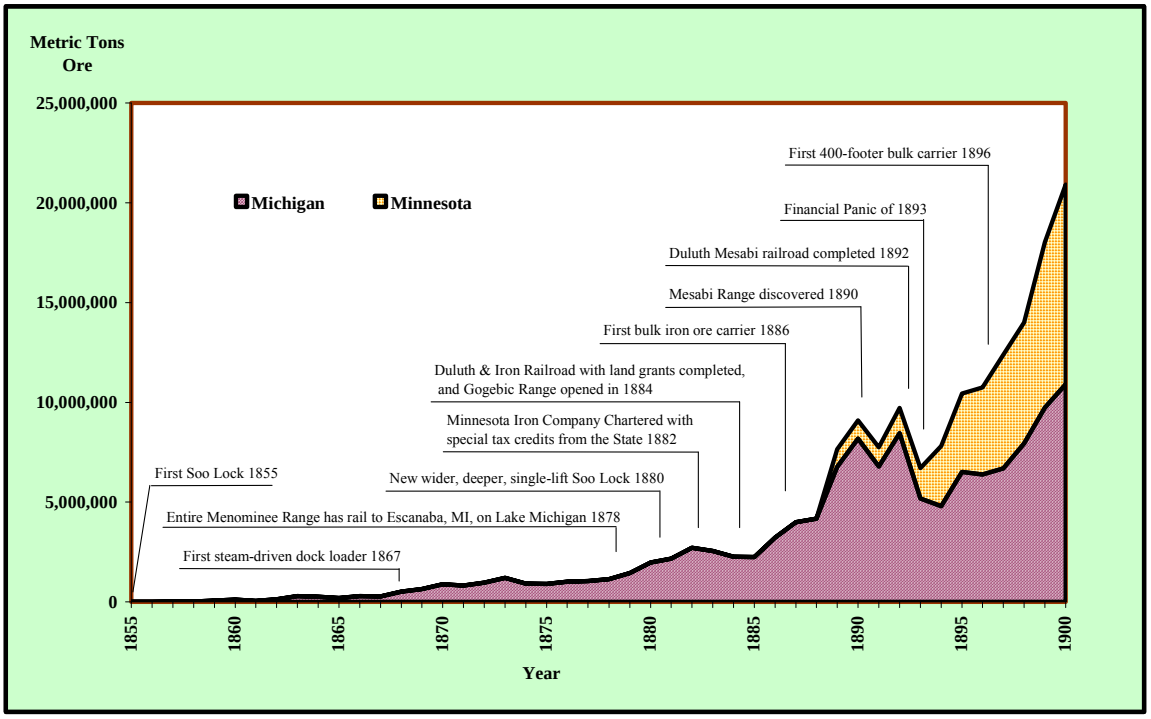
Figure 4. The modern Soo Locks, connecting Lake Superior to Lake Huron.

Photo credit: Green, 2000§.

The Soo Locks, improvements included, opened up the iron ore deposits of Michigan in 1870, and later, Minnesota's in the 1890s for development. This made possible the development of, what was for a time, the largest steelmaking industry in the world. With iron ore feedstock from the Lake Superior deposits, American steel mills were built along the shores of the Great Lakes, the Ohio River and its tributaries in Pennsylvania and Ohio (The Great Lakes Information Network, 2000).

Figure 5 shows the growth of iron ore production in the Lake Superior region during the 19th Century. The growth depicted was generated from a number of forces, including: technological advancement (steam engine loading facilities, bulk ore carriers), subsidized and private transportation advancement (Soo Locks and railroads), and new iron ore discoveries financed by capital from New York investors, and from overseas (Minnesota Historical Society, 1997§).

Figure 5. Nineteenth century Lake Superior iron ore production.



Source: Birkinbine, 1892, 1901.

Railroads:

The first railroad in the United States was built between 1827 and 1830 under a charter from the State of Maryland. It was a 21-km run from Baltimore to Ellicott Mills, Maryland, and horses provided the power to move freight and passengers at first. In late 1830, a small, locally made steam engine, the "Tom Thumb", was introduced to the new Baltimore and Ohio Railroad line, and American railroading was underway. By way of comparison, in 1860 there were about 6,400 km of canals in the United States, and 49,277 km of track (National Railroad Museum, 1999§).

Mineral development in the Great Lakes region started with canals, but railroads were the major impetus. Even with the inexpensive transportation afforded by bulk shipments of ores

on the Great Lakes, that ore still had to be moved overland from the mines to a port. This fact has created a rich history about short, dedicated, rail spurs from mine to harbor. For example, the Quincy and Torch Lake Railroad moved copper on the Upper Peninsula of Michigan from the mine at Hancock, Michigan to the smelter at Lake Linden, Michigan (Musser, 1996§).

The iron ranges (Cuyuna, Mesabi, and Vermillion) of Minnesota, somewhat inland from the western end of Lake Superior, have a similar history. The first railroad of importance for shipping iron ore there is the Duluth and Iron Railroad. In 1844, the first cargoes of Minnesota iron ore consisted of 2,560 metric tons (t) of "Vermillion Lump" hematite. Total shipments from the mine during 1884 amounted to 56,400 t (Minnesota Historical Society, 1997§).

The railroad that opened the iron mines of the Mesabi Range in Minnesota was the Duluth, Missabe and Northern Railroad, which was completed in 1892. This railroad served virtually all of the mines on the Mesabi Range, delivering the ore to Superior, Wisconsin, a port on Lake Superior (Minnesota Historical Society, 1997§).

Most of the small railroads associated with mining were privately financed, however, they almost always connected with part of the subsidized infrastructure (the canal system, or railroad trunklines). Railroad subsidization, while it began in the 1820s with government funded route surveys, and continued with land grants from the States, really grew with

Federal land grants, which were part of a general Federal policy to provide private access to the public lands.

Between 1850 and 1871, Congress, for the purpose of building the transcontinental railroad and telegraph system and settling the west, gave railroad builders huge tracts of public land through land grant legislation. In effect, railroads, which were usually federally chartered corporations, became agents of Federal and State public lands policy (The Land Council, 1998§). Table 5 lists the major railroad land grants.

HOW LAND GRANTS WORKED

The government granted alternate sections (the checkerboard pattern) of public land to the railroad. The railroad used part of the land for track, and some was sold to the public for the funds necessary to build the railroad. Residual land was retained by the railroads. In addition, the railroad companies had to build within a certain time period, provide service in perpetuity, and haul military and postal freight at reduced rates (The Land Council, 1998§).

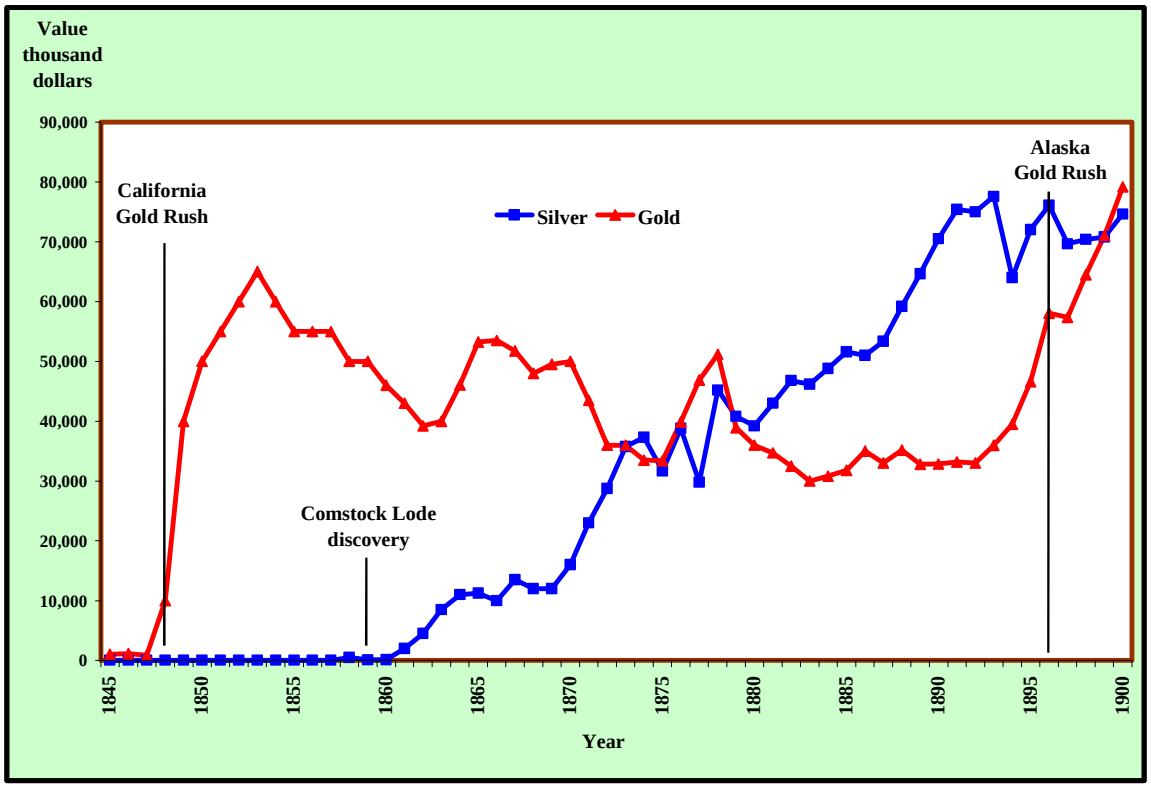
Table 5. Important Federal railroad land grants of the 19th Century.

Railroad	Year	Significance
Illinois Central	1850	First, established checkerboard pattern.
Chicago, Burlington and Quincy	1850	1.13 million hectares grant, 0.81 million of which were sold to 20,000 settlers.
Minnesota and Northwest	1854	Became Great Northern after numerous reorganizations.
Union Pacific Central Pacific	1862	To fund the transcontinental railroad, the Union Pacific got 4.45 million hectares and $27 million in bonds, and the Central Pacific got 3.24 million hectares and $24 million in bonds. Completed in 1869.

Extracted from: Draffan, 1999§.

The completion of the transcontinental railroad came 20 years after the peak of the California Gold Rush. Mineral exploration actually moved eastwards from California, and the next great discovery was the Comstock Lode near Virginia City, Nevada in 1859. The 19th Century production history of gold and silver is shown in Figure 6.

Figure 6. U.S. production of gold and silver in the 19th Century.



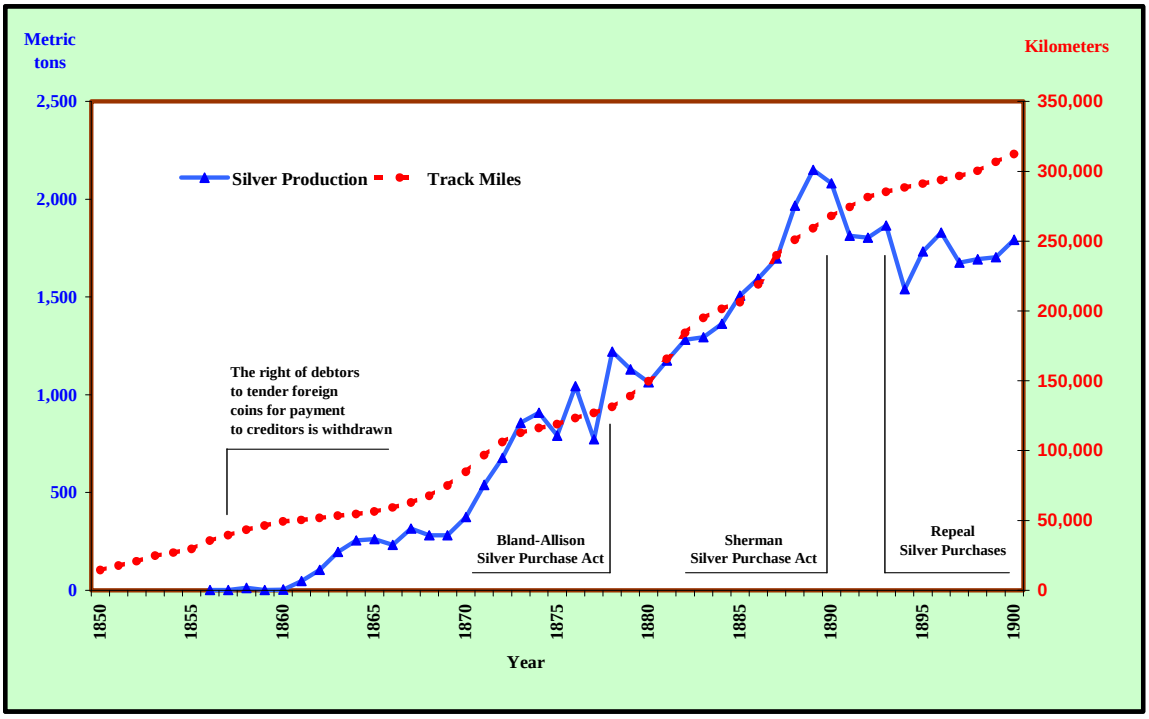
Source: Roberts, 1901.

With regard to the Comstock Lode, gold, having been discovered at the head of Six-Mile Canyon, Nevada, in 1859, was the first target of miners, but it soon became apparent that the real mineral of importance in the area was silver. Abraham Lincoln financed the Civil War domestically with fiat currency called Greenbacks, and overseas with silver, because of its

acceptance as "real" money. He made Nevada a State in 1864 even though it did not contain enough people to constitutionally authorize statehood (Bush, 1992§).

Emmons, 1900, analyzing the gold and silver industries of the 19th Century said, "[Gold] is largely produced from placer deposits, …., so that it can be extracted by simple processes requiring but little technical skill or scientific training. The reduction of silver from its ores…. requires…. not only the highest degree of technical and scientific knowledge and experience, but to render available any but exceptionally rich ores involves the expenditure of large capital in smelting plants, centrally situated and with easy and cheap railroad transportation to and from mining districts". Figure 7 shows U.S. silver production and track length.

Figure 7. Nineteenth century U.S. silver production, track-length, and policy.



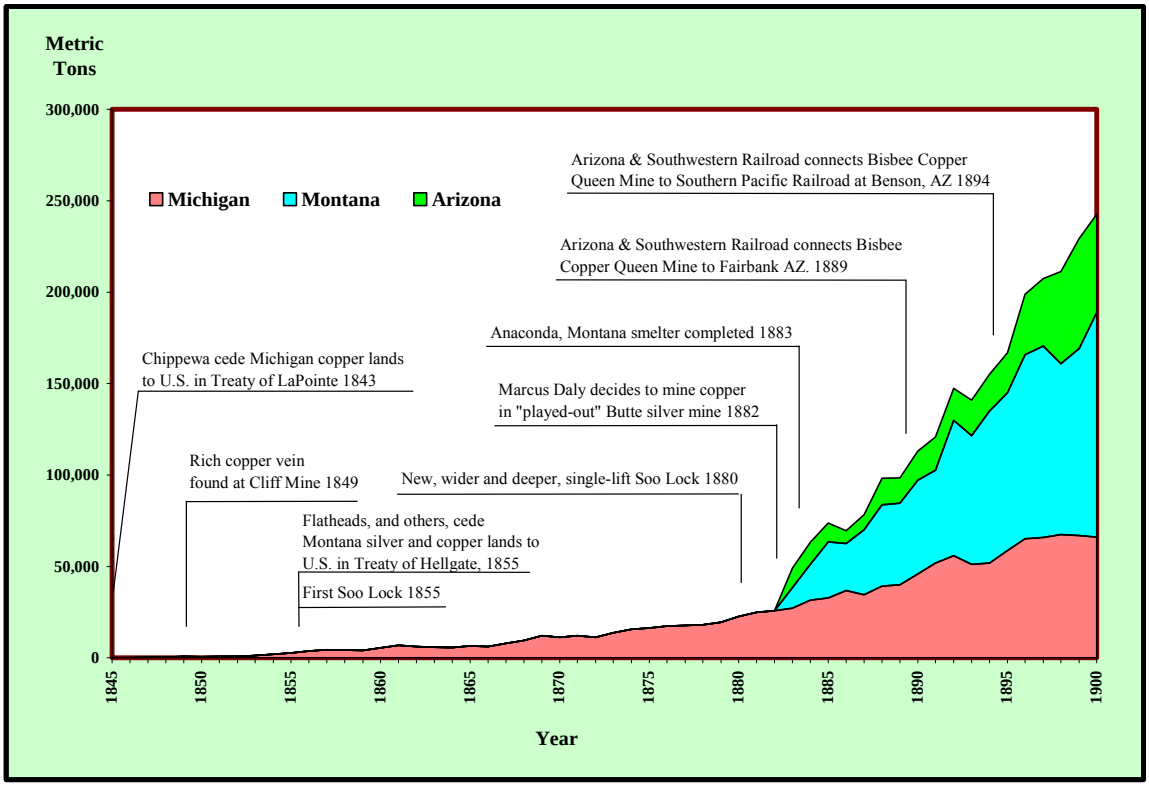
Source: Roberts, 1901; National Bureau of Economic Research, 1912§.

As silver mines were developed, privately funded mine railroads were connected to the federally supported transcontinental railroad, which provided access to smelters and markets. Throughout the latter half of the 19th Century, Colorado, Idaho, and Montana became mining havens, and mining became so important to the western economy that the problem of competing claims, discussed above, resulted in the passage of the Mining Law of 1872, which regulated the procedures for staking claims on Federal lands, working claims, and obtaining title (privatizing) to the minerals.

The Gadsden Purchase (Southern Arizona and New Mexico) by the Federal government from Mexico, 1853, completed the acquisition of land forming the contiguous 48 States. The purchase was designed to obtain suitable land for a southern route for a transcontinental railroad. Eventually, the Southern Pacific Railroad traversed the area, providing an east-west trunk line to which the short, copper-related, mine-specific, railroads could connect. This contributed to the development of the world-class copper mines of Arizona.

Figure 8 shows the relationship of 19th Century U.S. copper industry development to both land acquisition and infrastructure development policy.

Figure 8. Nineteenth Century U.S. copper production and historical events.



Source: Kirchhoff, 1901.

Bimetallic Monetary Policy:

The United States was on a bimetallic monetary standard since the passage of the Coinage Act of 1792, which established the dollar as the unit of account, subdivided it decimally into 100 cents, and created a value for the dollar in terms of both gold and silver (Davies and Davies, 1999§).

While silver supply is closely tied to the development of railroads (discussed above), there are certain pieces of 19th century silver-related legislation that directly affected silver mining in the United States. In 1857, legal tender status for foreign coins was withdrawn, and the demand for U.S. silver coins, previously satisfied by circulating Spanish silver coins,

grew, and silver production jumped ten-fold between 1857 and 1858 (Davies and Davies, 1999§, and Roberts, 1901). In 1878, the Bland-Allison Act, requiring the U.S. Treasury to purchase between $2 and $4 million worth of silver every month was passed at the behest of the silver lobby. This Act caused an increase in the 5-year average annual silver production by about 287,000 kilograms (Davies and Davies, 1999§, and Roberts, 1901). The Sherman Silver Purchase Act of 1890, until its repeal in 1893, required the Treasury to purchase 140,000 kilograms of silver per month. When the Act was repealed, 5-year average annual silver production dropped about 269,000 kilograms (Davies and Davies, 1999§, and Roberts, 1901). See Figure 7.

Summarizing the 19th Century progress of mining in the United States, one can see the importance of policies based on the support for development. Pennsylvania anthracite coal (1830s and 40s) was developed to fuel the steam engine and iron industries with State funded canals. California gold (1850s), Nevada silver (1860s and 70s), Michigan iron and copper (1860 – 1900), Montana silver and copper (1880s), Arizona copper (1880s), Alaska gold (1890s), and Minnesota iron (1890s) were all facilitated by definitive government policies to acquire land, remove and control the Indians, privatize the land in the hands of the developers (primarily by means of the General Mining Law of 1872), and subsidize transportation infrastructure.

THE END OF AN ERA

As quoted from the 1890 census report: "Up to and including 1880 the country had a frontier settlement, but at present the unsettled area has been so broken into by isolated bodies of settlement that there can hardly be said to be a frontier line. In the discussion of its extent, its westward movement, etc., it can not, therefore, any longer have a place in the census reports."

Source: The University of Virginia, undated§.

The overall effect on the minerals industry was positive from a producer's point of view. Fortunes were being made, and sometimes lost, in iron, copper, gold, and silver. However, by the time of the closing (1890) of the frontier, environmental concerns, first about conservation of resources, then about the pollution generated by resource extraction and use, gave rise to political action to control development. The term "sustainable development" is another expression embodying concepts of economic efficiency, social equity and responsibility, and environmental soundness to resource production decisionmaking (CAG Consultants, 1998§).

Post-Frontier Period (1891- present)

The use of the 1890 census as a benchmark to delineate two historical periods is a convenience, and does not imply that no one harbored concerns for the environment before that time. In fact, the conservation movement, which gained political prominence in the Theodore Roosevelt Administration, traces its own history to the late 1840s (The Library of Congress, 2002§).

Development in the post-frontier period can be characterized as "controlled development." Controlled development means here that the placement of natural resources into the service of human needs and wants continues, but concerns about future minerals availability and the environmental consequences of development simultaneously generate a progressively growing set of inputs to development decisionmaking, which reshapes development in terms of what, where, when and how it will occur. Table 6 lists some of the pro-development legislation of the post-frontier period.

Table 6. Development legislation of the post-frontier period.

Legislation/Program	Year	Public Purpose
Indian Lands Leasing Act	1891	Authorized mineral leases on Indian land[1].
Stock Raising Homestead Act	1916	Authorized mineral location and claims on homestead claims[2].
Mineral Leasing Act	1920	Authorized and governs leasing of public lands for development of deposits of coal, oil, gas and other hydrocarbons, sulfur, phosphate, potassium, and sodium[3].
Various Acts to create Hydro-electric Dams	1933 to 1944	The "New Deal" featured the building of many high profile dams. These provided employment, river transportation, recreation, irrigation, and inexpensive electricity[4].
Mc Mahon Act	1946	Established the Atomic Energy Commission. Commission uranium purchases created an industry boom, until purchases ended in 1970[5].
Strategic and Critical Minerals Production Act	1950	Authorized government stockpiling of "strategic" minerals, effecting production subsidies for many[6].
Federal Aid Highway Act	1956	Authorized construction of the U.S. Interstate Highway System, increasing the demand for aggregates, cement and steel[7].
Intermodal Surface Transportation and Efficiency Act (ISTEA)	1991 to present	Continually funds transportation infrastructure expansion and repair, sustaining the construc-tion industry and its materials suppliers[8].

1. California State University, 2000§.
2. Feriancek, 2001b§.
3. U.S. Fish and Wildlife Service, 2000§.
4. U.S.Bureau of Reclamation, 2001§.
5. Uranium Institute in London, 1989§.
6. U.S. Department of Agriculture, 2000§.
7. Weingroff, R.F., 1996§.
8. U.S. Bureau of Transportation Statistics, undated§.

In 1891, Congress passed an amendment to previous Indian legislation providing for leasing mineral rights on Indian land. Prior to 1891, leasing Indian lands for mineral development was prohibited. The purpose of the legislation was to increase access to minerals, and it currently serves as the basis of oil and gas leasing on Indian lands (California State University, 2000§).

Theodore Roosevelt attained the Presidency on September 14, 1901, upon the death of William McKinley by assassination, and conservation became the cornerstone of domestic policy (The Library of Congress, 2002§). In 1908, President Roosevelt convened a White House Conference, and later authorized a National Conservation Commission report to make a complete inventory of natural resources (Eckes, 1979).

In 1916, Congress passed the Stock Raising Homestead Act separating the mineral rights from the surface rights for new public land homesteads, and retained them for the government. Any future miners were prohibited from injuring, damaging, or destroying the surface owner's permanent improvements and were required to pay for damage to crops caused by prospecting (Feriancek, 2001b§).

The passage of the Stock Raising Homestead Act ended a policy debate which started in 1901 about separating the surface of public lands known or believed to contain minerals for the purpose of agriculture, and reserving the mineral deposits for the Federal government, a concept similar to the 1807 laws and their application to lead leasing, discussed above. President Theodore Roosevelt, heavily influenced by conservation interests, promoted the separation, and western mining interests, having operated successfully under the General Mining Law of 1872, opposed it. The Act favored the Roosevelt position (Linsenmayer, 1964).

The most important historical event of 1916 was the entrance of the United States into World War I. The Great War, was fought, in large measure, over access to minerals, and battle tactics were aimed at economic vulnerabilities of the combatants (Eckes, 1979).

Professor Charles K. Leith, a prominent geologist from the renowned University of Wisconsin School of Precambrian Geology, was one of the early researchers of the Mesabi Iron Range (Dott, 2001). Dr. Leith was an advisor to President Wilson at Versailles, and, based on his observations of the importance of minerals in the war effort, an advocate for international arrangements to regulate the global struggle for minerals, developing them, but in a context of efficient use (Eckes, 1979).

In 1920, congress passed the Mineral Leasing Act, fearing mainly that the United States was running out of oil, and there was a need to preserve what was left in public ownership (R.E. Deery, U.S. Bureau of Land Management, written commun. 2002). The Act has effect to this day of authorizing and governing leasing of public lands for development of deposits of coal, oil, gas and other hydrocarbons, sulfur, phosphate, potassium, and sodium, all of which had become important during World War I. The Act contains provisions regarding rights-of-ways over Federal lands for pipelines. In contrast to hard rock minerals, which are governed by the Mining Law of 1872, which privatized resource ownership (described previously), fuel and fertilizer minerals (oil, gas, coal, phosphate, sodium minerals, sulfur, potash) on public lands can only be leased (fees and royalties paid to the government, which retains ownership) (U.S. Fish and Wildlife Service, 2000§).

The depth of the Great Depression occurred in 1933. Prices and production rates for most commodities were at all-time lows, and many were interested in developing a national mineral policy for the United States. One was Dr. Charles K. Leith, introduced above, who in 1933 was chairman of a group called The Mineral Inquiry (Leith, 1933). In discussing the

issue of a possible national mineral policy, Lieth provided a list of non-mineral policies that were impacting the minerals industry of the 1930s, including: policies of economic nationalism; tariffs and exchange restrictions; quotas; embargoes; price-fixing; haphazard and unequal taxes of all kinds, federal, state; and anti-trust laws. Citing these, he continued to advocate a national minerals policy (Leith, 1933).

One of the important measures taken to "fight" the Great Depression was public works dam building, started by President Herbert Hoover's authorization of the Boulder Dam on the Colorado River in Nevada in 1931. Dams were built for many reasons, including flood control, irrigation, and energy production. During the Franklin Roosevelt Administration, 1933–44, several high profile dams were constructed on American rivers. The Tennessee Valley Authority (TVA) Act, and the beginning of work on the Grand Coulee Dam on the Columbia River began in 1933. By 1944, The Hoover (formerly Boulder), Grand Coulee, Shasta, Bonneville, and several TVA dams were generating more than a third of U.S. electric power. The aluminum industry, being a large electric power consumer, located many new plants near this inexpensive power source. During World War II, eight new aluminum smelters were built directly by the government to support the increased demand for aluminum, which was driven by war requirements(University of California, 2001§).

Prior to the entrance of the United States into World War II, there was concern for mineral supply disruptions. Under the Strategic Minerals Act of 1939, the Bureau of Mines and the Geological Survey commenced a search for new and marginal sources of supply for seven strategic metals: antimony, chromium, manganese, mercury, nickel, tin, and tungsten.

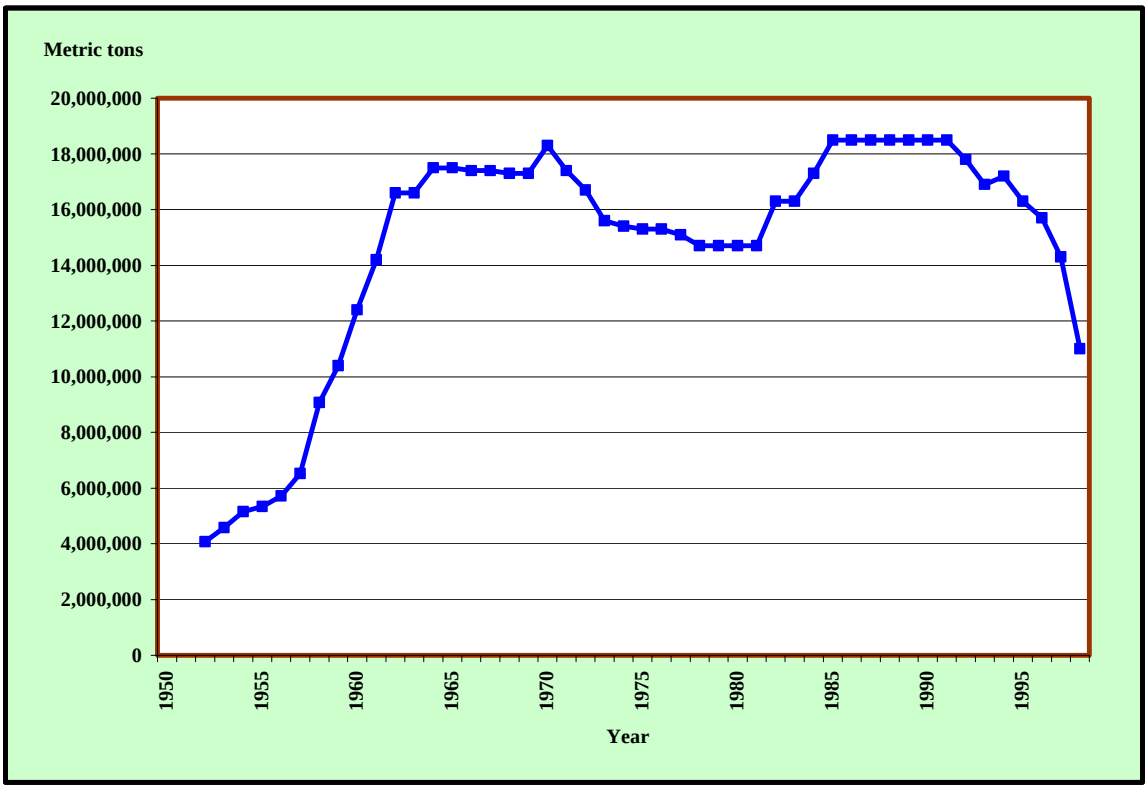
The study was expanded through the war years to 39 minerals, exclusive of many common industrial minerals, and reported out a set of minerals on which the U.S. would continue to have foreign dependency, including: chromite, ferro-grade manganese, nickel, platinum, tin, industrial diamonds, quartz crystal, and asbestos (U.S. Bureau of Mines and U.S. Geological Survey, 1948).

The McMahon Act of 1946 established the Atomic Energy Commission (AEC), and the commission unleashed a boom in the uranium industry through liberal incentives that lasted until 1967, when they were withdrawn. Between 1871 and 1905, U.S. uranium ore was used in glass and ceramics manufacture. Between 1906 and 1925, the major use for U.S. uranium ore was its radium content. From 1925–45, U.S. uranium ore was important for its vanadium content, vanadium having found an important market in specialty steelmaking. In 1948, the AEC established an ore-buying schedule and began purchasing (over 16 purchasing stations were created on the Colorado Plateau, where the ore deposits were located) uranium-vanadium ore, which stimulated mining (several idle mills were reopened) and exploration. Cumulative purchases from 1942 through 1970, when AEC procurement ended, amounted to 283,000 t of U_3O_8. U.S. producers supplied 156,000 t (55 percent) (Uranium Institute in London, 1989§).

Post World War II mineral policy was grounded in the concept of strategic minerals, and assuring the Nation's access to them. In 1950, during the Korean War, Congress passed the Strategic and Critical Minerals Production Act (SCMSPA), which was designed to store quantities of materials sufficient to sustain the United States for a period of not less than

three years during a national emergency situation (U.S. Department of Agriculture, 2000§). Many commodities were purchased under the Act, but the levels in the strategic stockpile of most commodities have been sharply reduced by planned sales in the 1990s. Figure 9 shows how U.S. government bauxite stocks responded to the Act.

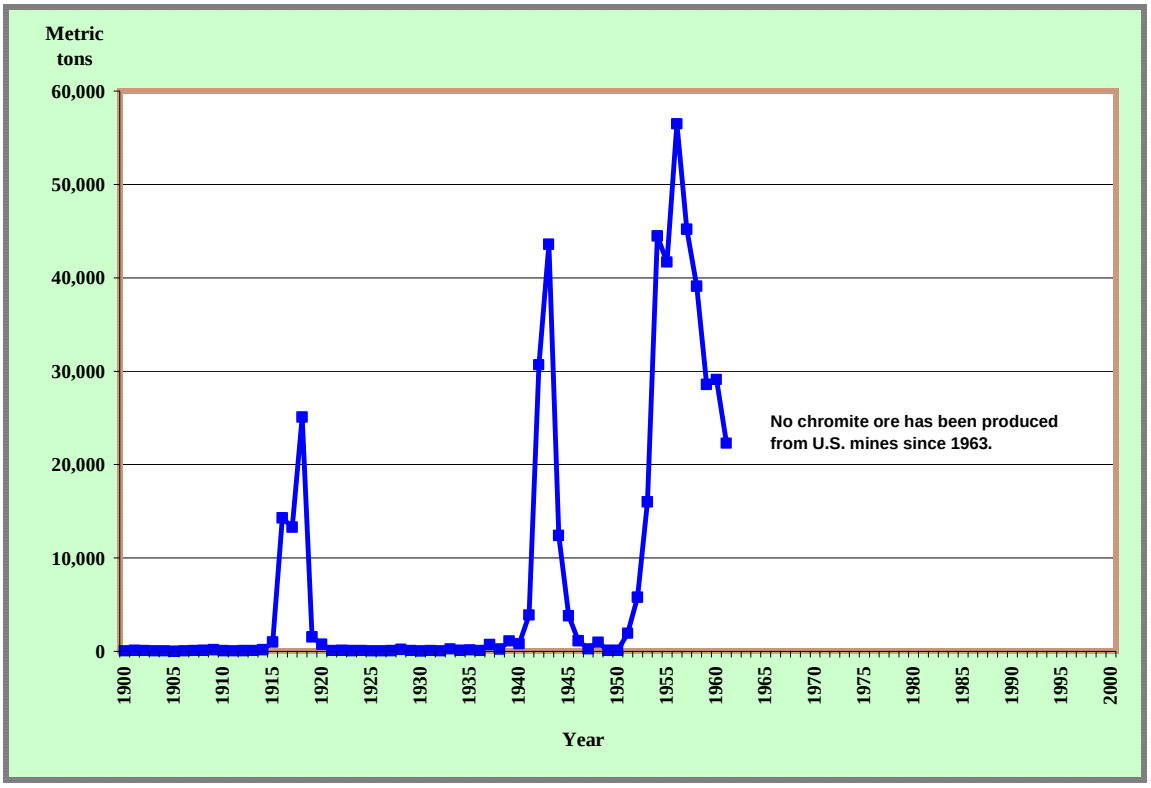
Figure 9. U.S. Government bauxite stocks, 1950–98.



Source: Kelly, and others, 2001§

Another commodity purchased under the Act was chromite, which is the main source of chromium used to make stainless steel. Resources of chromite ore in the United States do exist, but are relatively small in comparison to commercial deposits elsewhere in the world. Figure 10 shows three spikes in U.S. chromite ore production: World War I, World War II, and the early 1950s when the SCMSPA was in effect.

Figure 10. Twentieth century U.S. chromite production.



Source: Kelly, and others, 2001§

On January 22, 1951, President Harry Truman constituted the President's Materials Policy (Paley) Commission to study the long-range materials needs of the Nation, as distinct from immediate strategic needs. The Paley Commission, named for William S. Paley, Chairman, published its findings in June, 1952 (President's Materials Policy Commission, The [U.S.], 1952). The Paley Commission believed that a materials policy should provide a framework for public programs to work with private policy and action, moving towards national objectives, within a free market (v. 1, p. 17). It recommended further that: government undertake high-risk exploration (v. 1, p. 29); percentage depletion be retained, because of its strong inducement to risk capital (v. 1, p. 35); small mining ventures be

directly subsidized (v. 1, p. 36); stockpile objectives be reviewed annually, and that buy American rules be repealed to minimize cost (v. 1, p. 164).

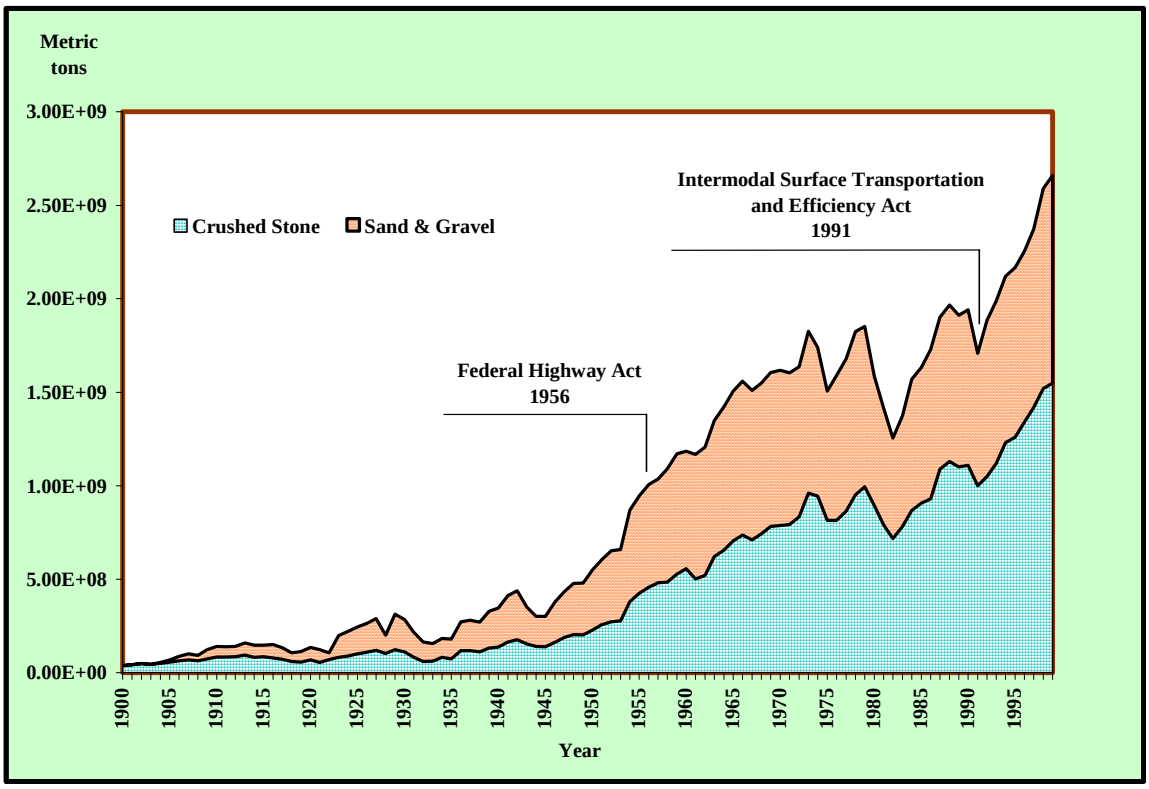
In 1956, Congress passed the Federal –Aid Highway Act. The idea of transcontinental superhighways first surfaced in the form of a study under the Franklin Roosevelt administration in 1938. In 1939, President Roosevelt recommended that Congress consider funding a system of such highways. Sixteen years of debate preceded the passage of the Act of 1955, and the interstate highway system has been under construction and repair ever since (Weingroff, R.F., 1996§).

Aggregates—crushed stone, sand, and gravel— is the largest mining industry in the United States. In 1945, annual aggregates production stood at about 400,000,000 t. Fifty years later, in 1995, annual aggregates production was 1,250,000,000 t. The construction of the National Highway System was one of the major causes of this growth (Tepordei, 2001).

In 1991, Congress passed the Intermodal Surface Transportation and Efficiency Act (ISTEA). This Act funds transportation projects, distributing money to the States by formula. It has the effect of maintaining and promoting the production of minerals, primarily aggregates (sand and gravel and crushed stone) for use in cement and/or asphaltic concrete. Some of the values that underlie the Act can be seen in the purpose of the Act, namely, "to foster a sound financial base for transportation; keep the industry strong and competitive; promote safety; protect the environment and improve the quality of life; and advance U.S.

technology and expertise" (U.S. Bureau of Transportation Statistics, undated§). Figure 11 shows the growth of the aggregates industry over the greater part of the post-frontier period.

Figure 11. Aggregates industry growth, 1900–99.



Source: Tepordei, 2001

The aggregates industry produces about 71 percent of all materials annually placed in service by Americans (Goonan, 1999§). In the words of the industry's association (National Stone, Sand and Gravel Association, 2001§):

> "Getting products to domestic markets and ports for export is critically important to our nation's economic growth. We want to grow safely and we want to grow efficiently to enable us to compete as a leading member in world commerce. Our national infrastructure is, to a large extent, dependent on crushed stone. Without highways, mass transit, airports, water systems and rail, we can't grow as a country. In 1991, Congress passed transportation legislation called the Intermodal Surface Transportation Efficiency Act that authorizes $151 billion to be spent over six years.

The Act recognizes our country's great need to construct new roads, expand existing ones, improve ports, bridges, airports and railways."

Table 7. U.S. land use statistics.

Land Use	Million Hectares	Percent (rounded)
Agriculture	479	52.0
Forest	296	32.0
Cities and Towns	32	3.0
Roads, Rails, Airports	13	1.0
Mine	2	0.2
Other	98	11.0
Total	920	100.0

Source: Minerals Information Institute, 1993§

Table 7 shows land use in the United States as of 1993. As shown, mining is a minor user of the total land area, and its major product, aggregates that make up cities, towns, and transportation infrastructure, is also a minor component of total land area.

The development-encouraging Federal laws, shown in Table 8, demonstrate that the public still values the benefits of development. Next, some of the national laws, derived from values that address the issues of development consequences, are discussed. These laws indirectly impact supply by altering production costs, access to mineral deposits, and timelines for decisionmaking (risk).

Table 8. Legislation driven by concerns about the consequences of development.

Legislation (as revised)	Year	Public Purpose
Organic Act, (Forest Management Act)	1897	Sets aside Federal forest reserves[1].
American Antiquities Act	1906	Permits the President to set aside land as non-developable[2].
National Park Service Organic Act	1916	Permits large tracts of land to be set aside from development[3].
Clean Air Act	1955	Calls for air emissions limits on identified substances, given certain conditions[4].
Wilderness Act	1964	Prohibits mining in areas designated as wilderness[5].
National Environmental Policy Act	1969	Prescribes Environmental Impact Assessments for development projects on Federal lands[6], and for all activities requiring a Federal permit.
Mining and Minerals Policy Act	1970	Fosters private mineral development, and wise and efficient use, and reclamation[7].
Federal Water Pollution Control Act	1972	Prescribes levels of quality for discharges to the nation's surface waters, and a system of permits[8].
Endangered Species Act	1973	Requires listing species near extinction, and requires consideration of these within permitting[9].
Federal Land Policy and Management Act (FLPMA)	1976	Requires Federal land managers to "balance" and plan public land use among competing interests[10].
Surface Mining Control and Reclamation Act	1977	Requires reclamation of land mined for coal[11].
Archeological Resources Protection Act	1979	Establishes mechanisms for identifying and protecting sites having archeological value[12].
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).	1980	Lists sites for clean-up, and establishes regimes of liability for adverse impacts to the environment from development projects[13].
Deep Seabed Hard Mineral Resources Act (DSHMRA)	1980	Establishes protocols and permit procedures for development of seabed minerals[14].

1. American Logger's Solidarity, 2000§.
2. U.S. National Park Service, 2000a§.
3. U.S. National Park Service, 2000b§.
4. Atmospheric and Meteorological Society, undated§.
5. U.S. National Wilderness Preservation System, undated§.
6. U.S. Department of Energy, undated§.
7. University of New Mexico, undateda§.
8. U.S. Environmental Protection Agency, 1972§.
9. U.S. Bureau of Reclamation, undated§.
10. University of New Mexico, undatedb§.
11. U.S. Office of Surface Mining, undated§.
12. U.S. Bureau of Land Management, undated§
13. U.S. Environmental Protection Agency, 2001§.
14. U.S. National Oceanic and Atmospheric Administration, 1998§

When it was realized that the frontier had closed, and unlimited development could no longer be physically accommodated, the values underlying development were still there, but the reality of limits seemed to transform thinking towards conservation (The University of Virginia, undated§).

The establishment of the national forests with the Forest Management Act of 1897 is reflective of the conservation drive (American Logger's Solidarity, 2000§). It is arguable whether this particular law had any impact on mineral supply since important deposits have been developed within national forests. However, this legislation does serve to mark the beginning of the period of controlled development when other value sets began to achieve prominence.

The American Antiquities Act of 1906, originally designed to preserve cultural artifacts, has had an impact on mineral development by removing land from access by mining interests (U.S. National Park Service, 2000a§). A recent example was the Executive Order (citing the authority of the Antiquities Act) establishing the Grand Staircase-Escalante National Monument in Utah, which appears to preclude the development of very low sulfur coal located there (U.S. Bureau of Land Management, 2001§).

The National Park Service Act of 1916 represented a clear success for non-development values. The legislation limits most development, including most access to minerals, within

national parks. On December 31, 1999, there were 33.8 million hectares of land inside the boundaries of national parks (U.S. National Park Service, 2001a§).

Policies to protect parks, reflecting environmental values, have included the challenging of development rights on private land proximate to national parks when adverse consequences are perceived. The Federal government purchased the New World Mine, a past-producing gold property, in 1996 because of such perceptions (U.S. National Council for Science and the Environment, 2001§).

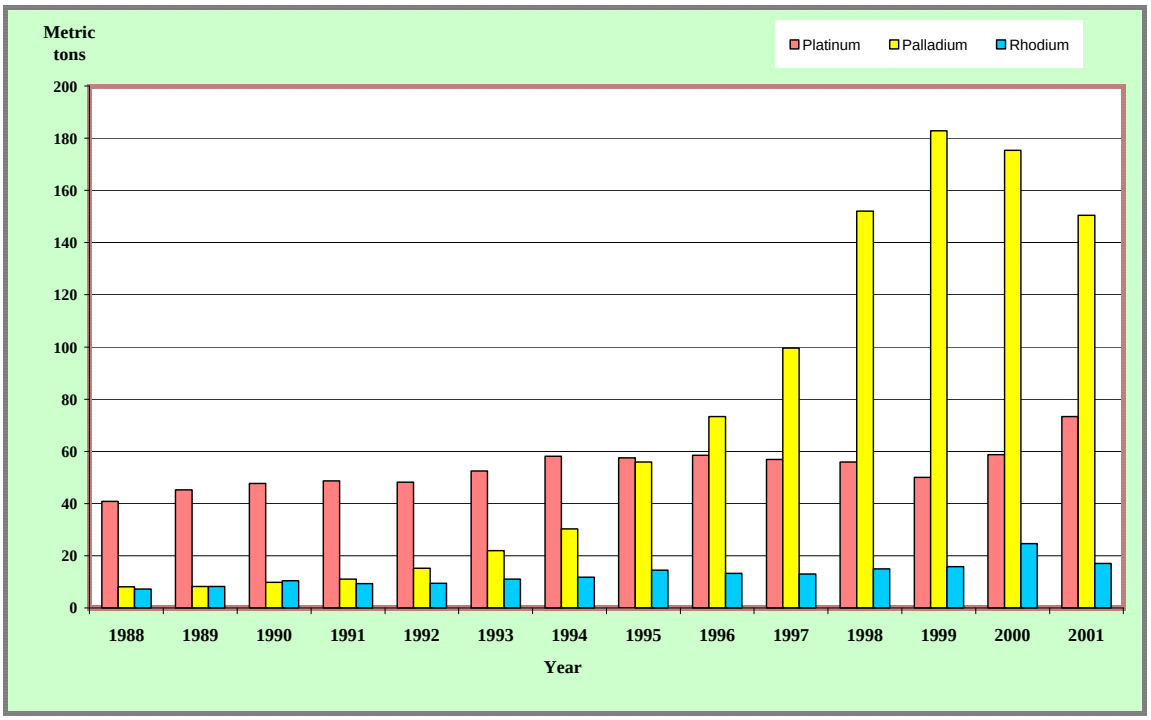
Interest in clean air goes back to 1900. Local governments passed smoke ordinances, and promoted electrification of public transportation to reduce smoke. The Clean Air Act, as it exists today, is a collection of amendments to the original 1955 legislation. It evolved from authorized studies of the problem of air pollution to specific emission limits, for specific substances, and instituted the granting of permits to polluting industries. These permits were/are based on some, or all of the following: specific emission limits, ambient air conditions (prevailing, or targeted), and efficiency assessments of available technologies (Atmospheric and Meteorological Society, undated§).

Sulfur, as sulfur dioxide (SO_2), which has been the subject for case studies in the companion reports of this series, is one element controlled by the Clean Air Act. Sulfur is prominent in the ores of copper, lead, and zinc, and the technology of smelting for all three have undergone major revision in response to controls of SO_2, a product of smelting sulfide ores. High-intensity oxygen smelting has replaced reverberatory furnace smelting to allow capture of high-concentration SO_2 off-gas streams in sulfuric acid plants (Wilburn, and

others, 2001§). The Clean Air Act had a profound effect on the sulfur industry itself. Because of requirements to remove the sulfur from coal and natural gas, sulfur recovered from these sources has reduced the need to mine sulfur from natural sulfur deposits (Wilburn, and others, 2001§).

The platinum group metals (PGM) industry provides an example where demand for metals was greatly enhanced by the Clean Air Act. Platinum, palladium, and rhodium are used in automobile exhausts systems, where they act as reduction catalysts to aid reduction of nitrogen oxides to nitrogen, and as oxidation catalysts to aid oxidation of carbon monoxide and unburned hydro-carbons to water and carbon dioxide. When the clean air amendments first called for this technology, standards were lower than today, and platinum supplies were sufficient to meet the standard. Later amendments to the Clean Air Act created more stringent standards, and demand for palladium, which is required to meet the higher standards, rose accordingly (Cowley and Hankin, 2001). Figure 12 shows the world consumption of platinum, palladium, and rhodium within the catalytic converter market (automobiles) for the period 1988–98. In 1997, catalytic converter use was 39 percent of the total PGM market for these metals (Cowley and Hankin, 2001). More than 121,000 kilograms of PGM were used by the U.S. automotive industry in the manufacture of catalytic converters in 2000. Note the demand for palladium increasing after 1991. This was due to the tightening of air regulations requiring increased use of the more efficient palladium catalyst. In 2000 and 2001, high palladium prices caused catalyst makers to substitute less efficient, but cheaper platinum for palladium (Hilliard, 2001§).

Figure 12. World use of platinum, palladium, and rhodium for catalytic converters.



Source: Cowley and Hankin, 2001.

The Wilderness Act of 1964 prohibited, unless specifically authorized, new mineral patents on lands designated as wilderness (U.S. National Wilderness Preservation System, undated§). In 1998, there were 9.1 million hectares designated as either wilderness areas, or wilderness under study (U.S. Department of the Interior, undated§). The Act mandated mineral surveys by the U.S. Geological Survey and the U.S. Bureau of Mines on public lands recommended by the U.S. Bureau of Land Management as suitable for inclusion in the National Wilderness Preservation System before final designation as wilderness could be made (Beikman and others, 1983).

The National Environmental Policy Act (NEPA) of 1969 directs all Federal agencies to prepare Environmental Impact Statements (EIS) before development on public lands, and

requires public involvement on land management plans and issues. The EIS has become an integral part of the granting of permits to engage in mineral exploration, mine development, and expansion. The purpose of the Act was to require full disclosure of the consequences of development prior to undertaking it (U.S. Department of Energy, undated§). While tending to make mining more publicly acceptable, NEPA does tend to increase the time required to develop a property, even the decision whether to seek properties to develop. The requirement to complete an EIS has been adopted by many States as well, leading to the review of mining plans on non-Federal and private land.

The Mining and Minerals Policy Act of 1970 is now a prologue to the General Mining Act of 1872. It declares that it is continuing policy of the government to foster and encourage private enterprise in mining, minerals, metal and mineral reclamation industries. Furthermore, the Act assures that there will be steps taken to lessen the impacts of mining to the environment (University of New Mexico, undateda§).

Closely associated with the spirit of the Mining and Minerals Policy Act of 1970, a second law was passed by the 91st Congress, namely, the National Minerals Policy Act of 1970. This Act was to enhance environmental quality and conserve materials by developing national materials policy to utilize present resources and technology more efficiently, anticipate future materials requirements of the Nation and the world, and to make recommendations on the supply, use, recovery, and disposal of materials. To that end, the Act established the National (Boyd) Commission on Materials Policy (National Commission on Minerals Policy, The, 1973, p. 9).

The Boyd Commission recognized that management of environmental resources is as important to national well being as the exploitation and use of minerals and energy, and that the economy and the environment are not polar interests; they are part of the same system. Accordingly, the following recommendations were made: 1. Environmental costs should be considered in total project costs, 2. Except where social benefits are paramount, limit mineral exploitation to areas where the ecosystem can be rehabilitated, 3. Federal research support for studies to determine the interaction of minerals exploitation and human, animal, and plant life, 4. Maintain reliance on free market to determine import/export balances, 5. Facilitate mineral access to public and private land, 6. Federal Government should expedite decisionmaking in the minerals, energy, environment area, 7. Federal Government should facilitate development of fossil fuel energy independence, 8. Federal Government should promote consumer product standards for safety, service life, recyclability, and life expectancy, 9. A resource recovery system be established, 10. Create a resource-recovery database, 11. Establish a comprehensive land use planning mechanism, and 12. Consider a Cabinet-level Department of Natural Resources for coordinated planning of materials, energy, and environmental use (National Commission on Minerals Policy, The, 1973, p. 1.3-1.8).

The 1972 Federal Water Pollution Control Act brought Federal authority into the arena of water pollution control. Currently, Federal standards for "clean" water govern when considering and permitting new projects. The Water Quality Improvement Act of 1970, again expanded Federal authority, and established a State certification procedure to prevent

degradation of water below applicable standards (U.S. Environmental Protection Agency, 1972§).

Most mining activities have to deal with water, whether storing, using, or re-routing it, but ultimately, at least some of it must be discharged to the nations streams and rivers. Obtaining permits takes time, and building process equipment to handle and treat and store water is an addition to production cost. Mining companies, located in arid areas, may be stimulated to conserve water, especially where flotation or leaching is a process step. Water issues are important with regard to where mining can occur, and to the selection of the appropriate technologies to employ.

STUDIES ABOUND

Between 1945 and 1979, more than 3,500 different studies and statements, by more than 40 government and private agencies, concerning minerals issues were completed (Pennsylvania State University, 1979).

Spurred by concerns about resource exhaustion, growing import dependency for materials, integration of materials issues into broader national and international policy, and the adequacy of the market to deal with shortages without causing hardships, the National (Eads) Commission on Supplies and Shortages published its findings in 1976 (National Commission on Supplies and Shortages, The, 1976). The Eads Commission concluded that resource scarcity was not likely to become a reality for the foreseeable future; short-term shortages, while always a possibility, could be managed through international agreements and trade facilitation; and materials data collection should be facilitated in all agencies with mandates to collect such data. The Commission also supported economic stockpiling, recycling, and

materials research and development (National Commission on Supplies and Shortages, The, 1976).

Table 8 lists some of the important legislation driven by concerns about the consequences of development. To save space, not all of the legislation listed in Table 8 is discussed in the text. Furthermore, there are several other pieces of legislation that are not listed in Table 8, including: the Emergency Planning Right to Know Act, an addition to CERCLA; the Occupational Safety and Health Act; The Pollution Prevention Act, the Surface Resources Act; the Toxic Substances Control Act; the Uranium Mill Tailings Radiation Control Act, the Wild and Scenic Rivers Act; and others. Additionally, there is a whole set of ever-changing tax legislation and regulation that has an impact on mineral production similar to those discussed above. All of these laws and regulations, based on quality-of-life values, and tax considerations, have changed the context (project cash flow) of mining decisionmaking over what it was in the frontier period. The effect, within the industry, of accommodating more values into mining decisionmaking is seen in industry consolidation, equipment and process changes (See URL http://pubs.usgs.gov/openfile/of01-197/). Some analysts suggest that these and open-ended permitting regimes have led to mining companies emphasizing operations outside the U. S. (R.E. Deery, U.S. Bureau of Land Management, written commun., 2002). Risk with regard to decisionmaking is discussed next.

The decision to deploy scarce capital in a mining venture is simple in concept, but difficult in application. The simple part is the idea that there is a profit to be made, the difficult part is trying to assess all of the risks attending the potential for a profit, and how

they will tend to diminish the return on the capital employed. Capital, being mobile, tends to be risk avoiding, or at least, minimizing (Anderson, 2000§).

Today, concerns about the consequences of mining have added to the list of risks that mining management must consider. The effect of conservation, health, and environmental values, expressed through laws and regulations, has not demonstrably limited the overall supply of minerals, but rather has determined the locus of production, moving it from areas of perceived high business risk to areas of lower risk. Quoting (Anderson, 2000§):

INTERNATIONAL MINING RISKS

1. **Political**
2. **Market**
3. **Transportation**
4. **Currency**
5. **Legal**
6. **Labor**
7. **Business**
8. **Geologic**
9. **Force Majeure**
10. **Environmental**
11. **Health and Safety**
12. **Infrastructure**
13. **Operational**
14. **Cultural**

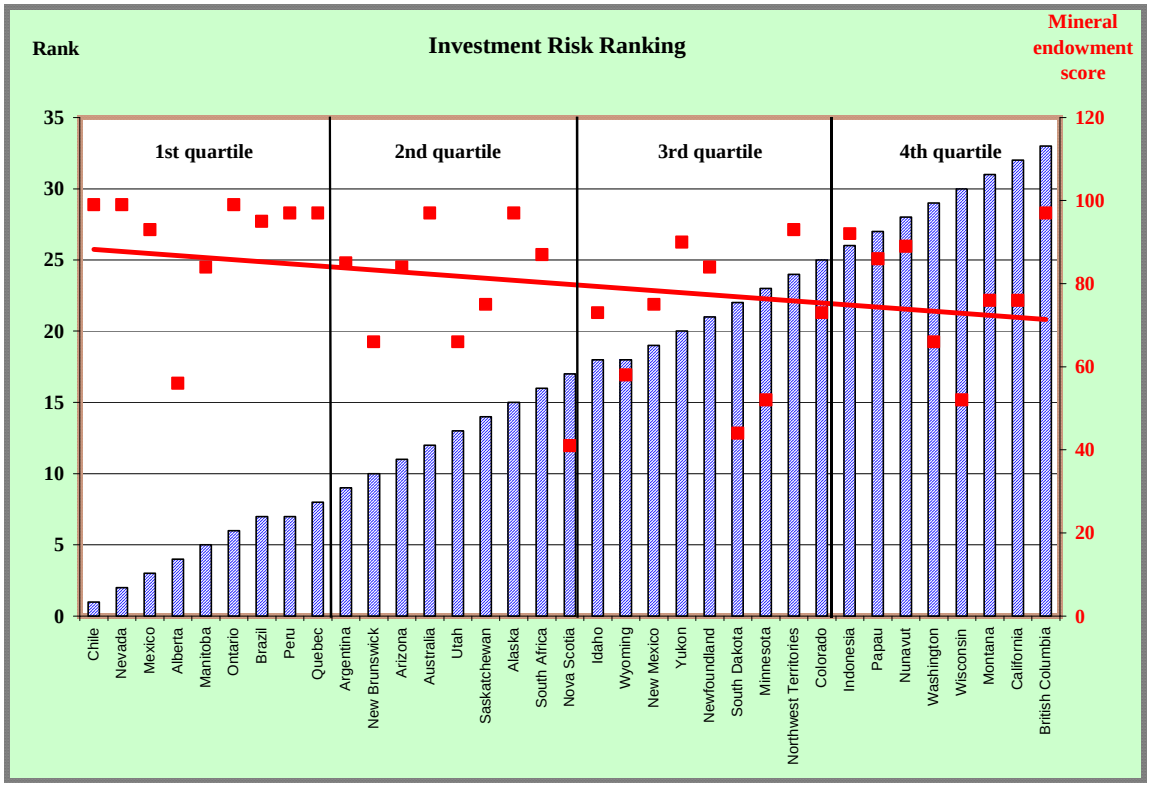
Source: Anderson, 2000§

> "Mining companies are sophisticated business enterprises, operating throughout the world. They routinely deploy the methods of risk management discussed above [in his paper]. As with any undertaking, the careful and rational consideration of the risk associated with that enterprise can help a company compete and succeed. No matter how much analytic force a company [may] bring to bear on its risk assessment, the future will remain opaque until it become[s] the present. Mining enterprises will therefore always require a certain amount of daring. You must be like Tennyson's Ulysses: 'strong in will to strive, to seek, to find, and not to yield'".

The Fraser Institute produces an annual survey of mining companies which, through interviews of executives, covers the investment climate for a geographic area of interest to the Institute's clients (The Fraser Institute, 2001§). Figure 13 recasts the Fraser Institute's

reported investment risk data, which includes: uncertainty concerning the administration, interpretation, and enforcement of existing regulations; environmental regulations; regulatory duplication and inconsistencies; native land claims uncertainty; wilderness and parks area uncertainty; infrastructure; labor regulation; socio-economic agreements; taxation; and mining potential.

Figure 13. Ranking of investment risk for selected political jurisdictions.



Source: The Fraser Institute, 2001§

The bars are investment rankings, and the trend line with square data points represent the Fraser estimate of mineral endowment of each geographic entity. The reason that 35 entities yield only 33 ranks is that there are two having equal values.

The risk is lowest for Chile, and highest for British Columbia. The red line shows that there is attractive mineral endowment in all risk quartiles. So, the decision to direct capital to a particular geographic area is made primarily on considerations of risk. From this chart, one

would expect mining capital to flow away from the fourth quartile entities (Indonesia, Papau, Nunavut, Washington State, Wisconsin, Montana, California, and British Columbia), and into first quartile entities (Chile, Nevada, Mexico, Alberta, Manitoba, Ontario, Brazil, Peru, and Quebec), based on these risk factors. Of course, the picture might be altered by other factors not considered here, for example a company having sunk costs in a region that has become unfavorable with respect to risk. Chile's economy has benefited immensely from an investment-friendly legal environment over the past 5 years (U.S. Department of State, 1999§).

Contrasting the frontier period and the post-frontier period, the frontier period was characterized by government encouragement, and sometimes subsidy, of development by means of land acquisition/disposal, and infrastructure (forts, roads, canals, and railroads) survey and construction. As the nation progressed into the post-frontier period, the corporate manager was still armed with government supports, but over time, had to consider many more values being expressed through legislation and regulation. Corporate managers must consider the views of stakeholders, all volunteering to add themselves, as spokespersons for quality-of-life values, to the decisionmaking process. The mining manager's task is to minimize corporate risk, to maximize corporate profits, so they tend to seek mining venues where the actual and perceived encumbrances are fewest. Mining has gone global as a response, but so too have the quality-of-life values.

5.5 RECENT DEVELOPMENTS IN GLOBAL MINERAL POLICY

Sustainable development is the name of the current milepost on the policy track of adding quality-of-life values to production decisionmaking. In 1987, the World Commission on Environment and Development released its report entitled *Our Common Future* (known as the Brundtland Report). The report defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Natural Resources Canada, 1995§). Sustainable development is the policy that is credited by many in academia, government, and transnational corporations as the correct model for production decisionmaking.

DIFFICULTIES IN OPERATIONALIZING SUSTAINABLE DEVELOPMENT

- **Nationalism may reject international treaties.**
- **Legal systems are not harmonious with sustainability goals.**
- **Economic and Environmental ministries are generally at cross-purposes.**
- **Institutions for enforcement are not present in all countries.**
- **Intra-generational goals of sustainable development require re-distribution of wealth, and entrenched forces for the status quo are powerful.**
- **In the absence of assistance from developed nations, poor nations cannot afford to implement stringent environmental laws.**
- **National policies are not consistent with local goals.**
- **Repeated resort to the legal system will undermine local cooperation with mining companies.**
- **Blocking the development of mines on principle may leave remote rural areas with few anti-poverty actions.**

Source: Shields and Solar, 2000.

The concept, sustainable development, has achieved wide acceptance largely due to its definitional ambiguity. It can mean different things to different people. For example, a mining executive might think of it as mining with concern for the environment, but others might think of it as deciding whether to mine or not. The common ground for each is risk assessment, the mine manager seeking the recovery of capital and profits, which the stockholders value, while others seek the maintenance or enhancement of social and environmental systems, which these stakeholders might value. The holistic approach, looking at the big picture and considering all interests, is the synthesis of the two views (Nieto, 1997§).

Two recent policy initiatives pertain to the mining industry in the global arena. The first initiative was put forth by the Organisation (sic) for Economic Cooperation and Development (OECD) as the Multilateral Agreement on Investment (MAI), which addresses worldwide capital flow. The MAI (Organisation for Economic Cooperation and Development, 2001§) states:

> "Foreign Direct Investment (FDI), together with international trade in goods and services, promotes economic growth, jobs and rising living standards worldwide. From 1973–96, FDI flows multiplied fourteen times from $25 billion to $350 billion per annum, outstripping growth in international trade."
>
> "Governments welcome FDI as a source of capital and innovation and as a means to promote competition and economic efficiency. Businesses of all sizes expand across national boundaries in search of new markets and creative partnerships. Consumers benefit from increased quality, wider choices and lower prices on the goods and services they buy."

Ten major mining companies have put forth the second initiative, the Global Mining Initiative (GMI). The GMI (Global Mining Initiative, 2001§):

> "seeks to ensure that the position of the mining and metals industry, whose products are essential for the well-being of a changing world, contain propositions with regard to global needs and challenges as well as the local environments and communities where they operate. The main purpose of the initiative is to work together with stakeholders to develop a clearer definition and a better understanding of the positive role that the mining and minerals industry can play in generating a transition to a sustainable pattern of economic development".

Historically, the globalization of mining has helped mineral supply keep pace with demand, at continually decreasing prices (Sullivan, and others, 2001). The relative political power of competing value systems continues to exert influence on where capital will flow into mining. Mineral extraction and production have consequences for people, whether they occur or not. The experience of these consequences will continue to inform the debate. It is therefore predictable that humans will continue to redefine production locations and levels on the basis of prevailing values.

5.6 CONCLUSION

The history of policy in the United States demonstrates a continual government support for development, either directly through subsidy, or indirectly by facilitating services that support development. In the frontier period, up to about 1890, the support for development was largely unrestrained, reflecting the government's need for revenue, which was an extension of colonial policy. Since 1890, when the frontier was proclaimed closed by the Census Bureau, other values pertaining to the preservation of ecological and cultural resources have come to the fore.

Even with added production constraints and policy-induced costs, production has been able to relocate and technologically respond to meet ever-increasing demand. In the future, the location and level of production will most likely continue to adjust to the new demands made on producers to add environmental values and considerations to their decisionmaking processes. Short-term supply dislocations, like those that occurred during World Wars I, and II, will continue to occur and raise concerns about availability and scarcity to juxtapose with environmental concerns, and in the long term, competing concerns deriving from competing values will find a workable compromise.

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