Abstract

Humankind has reached a pinnacle moment when the principles of sustainable living must be embraced or lost forever. Natural resource reserves are dwindling, greenhouse gas concentrations are rising, and toxic substances are accumulating in our environment at hazardous levels. Current free markets fail to value environmental goods properly, leading to massive over exploitation and environmental damage. If we are to move towards an era of sustainable development in which we satisfy our needs without compromising the ability of future generations to provide for themselves, we must embrace the principles of natural capitalism, by increasing the productivity of natural resources, shifting to biologically inspired production processes and reinvesting in natural capital.

Outline

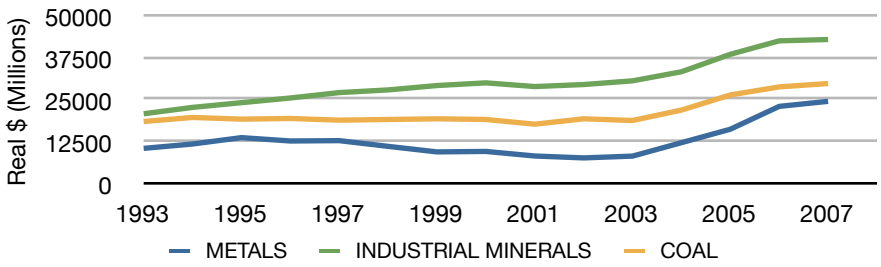
Th US population is growing at rates that are unprecedented in human history. Coupled with this exponential growth is increased dependence and use of natural commodities (USGS 2008). Every year each person in the U.S. requires more than 25,000 pounds of new non-fuel minerals to make the goods and provide the services that enable the high standard of living in the Unites States (Robertson YEAR). Natural resources are a key part of every industry in the United States and support fields such as medicine, transportation, and construction. Increased natural resource use has strained natural systems and negatively impacted the environmental increasing concentrations of greenhouse gases in the atmosphere, bioaccumulating toxins in our ecosystems, and increasing waste tremendously. The possibility of sustainable development exists only through drastic changes that must be made in the short term through a three-fold approach. First, environmental goods must be valued with a system that accounts for the full social cost of use. Second, efforts to reduce use and increase productivity must be made. Finally, production models must be redesigned to resemble zero-waste biological models accompanied by reinvestment in natural capital.

Key Commodity Groups

In the United States, mineral resources can be divided into three broad categories, as defined by the United States Geological Survey; metals, industrial minerals, and fuel sources (USGS 2008). The category metals includes iron ore, copper, lead, zinc, gold and other mined metals. US consumption of metals topped $25 billion in 2007 (USGS 2008). The category industrial minerals encompasses sand, gravel, stone, potash, soda ash and other industrial commodities. Consumption of these minerals was $43.2 billion dollars in 2007. The last category, fuel sources, includes coal, oil, natural gas, and other sources of energy. In 2007 the US consumed $30 billion dollars of coal alone. As demonstrated by the below graph (see Figure 1), commodity use and the value of commodities are growing quickly in the United States in every category discussed above. These three categories of raw materials accounted for nearly 10% of total spending in the United States and are certainly the basis of the production and consumption possibilities that afford us the high standard of living we enjoy every day (Committee on Earth Resources 1996).

Figure 1:

Commodity Use by Category
Based on data from USGS 2008 mineral resources yearbook (USGS 2008).

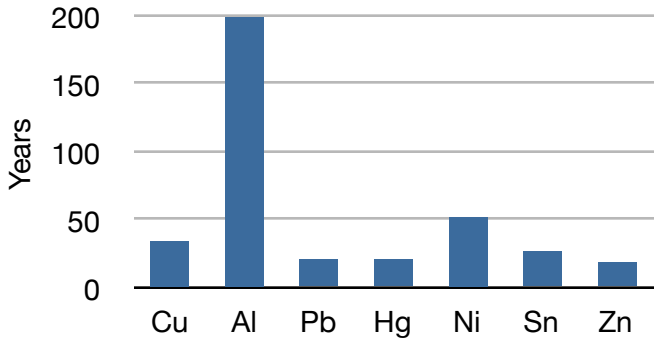


Resource Use

The United States holds a very small fraction of total world resource reserves, however we account for a disproportionately large fraction of total resource consumption (USGS 2008). In 2008 there were 19 mineral commodities used in the United Sates that were mined entirely outside of the United States. We imported at least half of 25 more mineral commodities we used (USGS 2008). The United Sates relies heavily on imports of mineral resources and is economically dependent on other countries (Wagner 2002). According to Ekins (1999) the supplies of several commonly used metals in the U.S. (e.g., Cu, Pb, Hg, Ni, Sn, Zn) will last only

decades (see figure 2). A R/P ratio of 10 indicates that at current rates of production, reserves are expected to last just 10 more years. Considering these data, at current levels of production, copper is estimated to become exhausted by around 2040, lead by 2015, and nickel by 2060. (Ekins 1999)

FIGURE 2: R/P Ratios for Various Minerals



Reserves of oil are expected to last 36 years, natural gas around 80 years and coal less than 140 years. (BP 2008) The implications of this are astounding. Unless drastic changes occur in the way we use commodities the earth will be nearly exhausted of many key resources within a century. A future of sustainable use is necessary to continue living at the same standards we enjoy today.

Sustainable Development

Sustainable development means satisfying the needs of humans today without compromising our ability to meet the needs of humans in the future. Absolute sustainability is no longer a possibility. If every citizen in every country enjoyed the standard of living that we live at in the United States, it would require four earths worth of resources to persist for just one year (Hawken *et.* al, 1999). While absolute sustainability is impossible, it is possible to change the way we use resources and provide a high standard of living for future generations through changing in methods for valuing environmental goods, increasing resource productivity, and using biological production models.

Valuing Environmental Goods

Environmental implications of materials use is crucial as these will be among the most important factors driving a future of sustainable use. The environmental implications of overuse of mineral commodities are more prevalent today than at any time in earths history (Committee on Earth Resources, 1996). The earth is closed system and no action is without consequence. Minerals are being added to the environment by anthropogenic sources in excess of the environments

capacity to absorb them (Wagner 1992). Depletion of the ozone layer, the addition of greenhouse gasses to the environment, loss of biodiversity, bioaccumulation of toxic substances, polluted rivers, smog and acid rain are all consequences of increased mining and consumption activities by humans (Wagner 1992). Currently natural commodities are valued based solely on their economic value. This free market approach fails to account for externalities associated with the extraction process. When an electricity company burns coal to produce electricity it creates nitrous oxides and sulphur dioxide which contribute to respiratory disease, damage to crops and trees, and acidification of waterways (Turner et al. 1993). When buying coal or charging for electricity the costs of the negative externalities (e.g. increased respiratory disease) are never taken into account. Thus, the true cost of burning coal is never accounted for in our market system. Sustainable development will require that externalities are taken into account when pricing goods, through government intervention and policy.

Increasing Productivity

The industrial revolution and the rapid growth in human populations during the last century have lead to drastic and rapid changes in the earth's surface and mineral stocks (Hawken *et.* al, 1999). As natural commodity supplies continue to diminish drastic changes in production models will be requires for sustainable development. By radically increasing the productivity of natural resources through technology and innovations we can increase productivity by orders of magnitude and cause a new natural industrial revolution. We can see productivity growth like the growth we saw with inventions like the cotton gin, printing press, and plow, which increased productivity by 100s of times and decreased the amount of labor required for daily tasks. Through research and development we can find innovations that we cannot even imagine today that can again cause a new industrial revolution. In the near future companies will be rewarded for efficiency and waste reduction, leading to an economy that is no longer based on exhausting resources but rather is based on sustainability and living within environmental limits (Hawken *et.* al, 1999). Increases in productivity will mean using the same amount of inputs to produce much more output. This transformation in productivity is a key aspect of a sustainable future.

Biological models

Finally for true sustainable development to occur, we must shift to biologically inspired models of production that feature closed systems without waste (Hawkens 1999). In closed-loop production systems, as seen in nature, every output is either returned harmlessly to the ecosystem, or becomes an input for another manufacturing process. We too can create these ultra efficient production systems that will lead to sustainability. We must also reinvest in natural capital and work to undo the changes we have caused on the planet. A true model of sustainability will incorporate the ideas of increased resource productivity, biologically inspired production models, and reinvestment in natural capital.

Conclusion

Mineral resource use has reached unsustainable levels in recent years. If we are to truly leave resources for future generations we must embrace the principles set forth by Paul Hawken in his novel *Natural Capitalism*. We must invest in research and development to make current production systems more efficient and based more on natural systems which eliminate waste. Sustainable development is possible, and will likely result from market forces, but the government and mankind have roles to play as stewards for a better future.

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