PROCEEDINGS OF THE AUSTRALIAN RANGELAND SOCIETY BIENNIAL CONFERENCE
Official publication of The Australian Rangeland Society

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Form of Reference
The reference for this article should be in this general form;

Author family name, initials (year). Title. *In*: Proceedings of the *n*th Australian Rangeland Society Biennial Conference. Pages. (Australian Rangeland Society: Australia).

For example:

Anderson, L., van Klinken, R. D., and Shepherd, D. (2008). Aerially surveying Mesquite *(Prosopis* spp.) in the Pilbara. *In*: 'A Climate of Change in the Rangelands. Proceedings of the 15th Australian Rangeland Society Biennial Conference'. (Ed. D. Orr) 4 pages. (Australian Rangeland Society: Australia).

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The Australian Rangeland Society

How global trends in population, energy use, water use, and climate impact on rangeland and rangeland users. Implications for policy development, land use and management, conservation and production

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Abstract. Increasing world human population, declining reserves of cheaply extracted fossil fuels, fresh water scarcity, and climatic instability will put tremendous pressure on world rangelands as the 21st century progresses. It is expected the world human population will increase by 40 percent by 2050 but fossil fuel and fresh water reserves will be drastically reduced. Avoiding food shortages and famine could be a major world challenge within the next 10 years. Under these conditions, major changes in basic world policies relating to economic growth and natural resource use seem essential. Human population stabilization; clean, renewable energy development; enhanced water yields and quality; increased livestock production; and changed land use policies that minimize agricultural land losses to development and fragmentation will all be needed to avoid declining living conditions at the global level. The health and productivity of rangelands will need to receive much more emphasis as they are the primary sources of vital ecosystem services and products essential to human life. Changes in tax policies by developed, affluent countries, such as the United States, Australia, and Canada, are needed that emphasize saving and conservation as opposed to excessive material consumption and land development. Extreme debt levels and chronic trade deficits by the United States and European Union countries must be moderated to avoid a devastating collision of debt, natural resource depletion, and environmental degradation. Over the next 10 years, range livestock producers will benefit from a major increase in demand and prices for meat. Rapidly increasing demand for meat in China is driving this trend. However, ranchers are also likely to encounter greater climatic, financial, biological, and political risks. Higher interest rates, higher production costs, and higher annual variability in forage resources are major challenges that will confront ranchers in the years ahead. Under these conditions, a low risk approach to range livestock production is recommended that involves conservative stocking, use of highly adapted livestock, and application of range livestock behavioral knowledge to efficiently use forage resources.

Introduction

World rangelands and ranchers over the next 10 years will undoubtedly be affected by increasing human populations, energy use, water use and climatic volatility that are now in progress. The rise of China and India, with 2.5 billion people (36 percent of the world's population), are the major drivers in the accelerated demand for natural resources and food that is now shaking the world (Leeb 2011, Casey 2012). Over the past 30 years, the world has moved towards much greater economic specialization and globalization at the expense of diversification and local sufficiency. This has given people in the affluent western countries (United States, European Union, Australia, Canada, New Zealand) access to high quantities of cheap goods and food while allowing the large developing Asian countries (China, India) to modernize their economies and improve living conditions for millions of people. Unfortunately, the world economy as it now exists is on an unsustainable path due to massive trade imbalances (huge debt accumulation by the western countries that is owed primarily to the Asian countries), depletion of essential natural resources, and degradation of vital ecosystem services with climatic instability at the forefront. Six basic natural resource categories that include fossil fuels (especially oil), fresh water, farmland, phosphorus, copper and rare earth elements (neodymium, lanthanum, indium etc.) essential to human welfare and progress, are projected to reach peaks within the next 40 to 50 years followed by shortages if current trends in human population growth and resource consumption continue (Kuntsler 2005, Heinberg 2007, Friedman 2008, Cribb 2010, Brown 2011, Leeb 2011). The interaction and convergence of debt, resource depletion, and environmental degradation are discussed in detail by Kuntsler (2005), Leeb (2009, 2011), Smith (2010), and Brown (2011) are particularly alarming. However, I believe that if modifications are made in the world model for economic development, sustained global prosperity is possible.

Rangelands, which comprise about 70 percent of the world's land area, are primary sources of basic ecosystem services, provide essential natural resources, and are important in food production. They will definitely play a critical role in how the future plays out. The primary objective of my paper will be to examine how global trends in the human population, energy use, water use, and climatic change will impact rangelands and rangeland users. After considering these issues, I will discuss the implications from policy, conservation, and producer standpoints. My secondary objective is to identify primary sources of information for readers seeking more depth and detail on this important subject area than I can provide in my brief paper.

Human Population Growth and Food

Human population growth is the primary driver of rapidly increasing demand for food, energy, water, recreation, and other rangeland products. The world human population reached 7 billion in 2011 compared to 2 billion in 1930 according to the United Nations. The annual growth rate is presently about 1.1 percent which is a drop from 1.4 percent in 2000 and 2.0 percent in 1960 (USDC 2011). However, if food is adequate, demographic experts project the world human population could reach 12 billion before stabilizing (Friedman 2008, Brown 2009, 2011, Cribb 2010, Smith 2010). The decline in human population growth rates first came from developed countries but has become globalized with the exception of central and east African countries where fertility rates are still above 4 or more children per woman. Africa is the continent presently most at risk of famine (Brown 2008, Cribb 2010). Religious beliefs, family labor needs, lack of reproductive freedom for women, lack of education on birth control, and lack of contraceptives largely explain the high birthrates in most African countries. Looking 10 years into the future, both China and India, the world's two most populous countries (36% of world's population), are also at risk of famine. This is due to farmland conversion to other uses, loss of the glaciers in the Himalayas, ground water depletion, groundwater contamination, soil erosion, climatic instability, and population increases (Cribb 2010, Brown 2011). Impending peaks in oil and phosphorus extraction add to their risk of famine.

Critical basic resources needed to feed more people are being rapidly depleted (Friedeman 2008, Brown 2008, Cribb 2010, Leeb 2011). These include oil, water, farmland, phosphorus, and potash. Since Thomas Malthus in 1798 predicted the world would run out of food by 1850, there have been repeated forecasts of dire consequences (mostly famine) to the world's rapidly increasing population. However, food production has kept ahead of population growth due to "green revolution" farming practices and crop varieties that depend heavily on fossil fuel inputs in terms of fertilizer, cultivation, pesticides and irrigation. Now a slowing of yield increases from the green revolution, resource depletion (water, phosphorus, farm land) and climatic change are triggering new fears of future famine (Brown 2008, 2011, Cribb 2010). World food prices have been increasing for the past 5 years and world grain reserves are at historic lows. Beginning in 2008, food riots have occurred periodically in some Asian and African countries. Increasing political instability and government change in certain Mideastern countries (Egypt, Tunisia, Lybia, Syria) are linked with rising food prices. Based on estimates of the World Food and Agriculture Organization, the number of undernourished people in the world is growing at an alarming rate. Presently one in four people are considered to be malnourished. The potential peaking of world oil production has been considered to be the biggest threat to feeding the world's population. However, most recently, phosphorus depletion (an essential crop nutrient that cannot be synthesized like nitrogen) has emerged as potentially more critical than oil (Cribb 2010). The rapid rise in world food prices and spread of malnutrition that is now occurring is causing doubt that the world human population can rise very much beyond its present level (Cribb 2010, Brown 2008, 2011).

Both human population and economic development will have considerable influence on how rangelands will be used. As an example, over the past 10 years, large areas of the Pampas rangelands in Argentina have been converted to farmland for soybean production that is exported to China (Casey 2012). Conversely, large rain forest areas in Brazil have been converted into grazing lands for livestock. Within China's western and northern provinces, cattle, sheep and goat populations have drastically increased since the 1980's putting severe pressure on the vegetation (Brown 2008, 2011). This is causing large scale degration of rangeland into desert. Rangeland resources in North African and Mideastern countries are also under intense pressure due to human population increases. Rangelands will be much more important for meat production in coming years due to a rising human population that desires more meat in its diet. China is the country at the forefront of increasing per capita demand for meat.

Oil and Nuclear Power

Oil is the most important source of energy in the world. It supplies 33% of the world energy needs followed by coal (27%), gas (21%), renewable sources (13%), and nuclear power (6%) according to the United States Energy Information Administration. Since 2000, world demand for oil has increased about 1.3 percent per year compared to world population growth of 1.1 percent per year. Oil is the natural resource most likely to constrain human populations and progress (Simmons 2005, Tertzakian 2006, Rubin 2009, Steiner 2009, Bryce 2010). Several energy experts are concerned that global production could peak within the next 2 to 30 years (Simmons 2005, USGAO 2007, Rubin 2009, Steiner 2009, Leeb 2011). No alternative energy sources have the potency of oil in terms of energy output per unit of input or ease of handling. Various alternatives such as natural gas, coal, nuclear power, wood, ethanol, wind, solar, geothermal, and tidal, all have energy yields that are 50 percent or less than that of oil (Rubin 2009, Steiner 2009, Bryce 2010). In summary, oil depletion will make it more challenging to maintain the energy needs for a growing human population (Simmons 2005, Rubin 2009, Steiner 2009). Travel, basic goods, and food will undoubtedly become much more expensive as oil supplies are depleted (Rubin 2009, Steiner 2009). In addition to being the world's primary energy source, oil is also a critical constituent of plastics, pesticides, asphalt, and various chemicals vital to modern society (Simmons 2005).

"Peak oil" is a term commonly used in reference to global oil production reaching a maximum and then declining due to depletion of finite reserves under stable or increasing demand (Simmons 2005, USGAO 2007, Bryce 2010). Peak oil will likely occur between now and the year 2040, depending on a variety of factors (Simmons 2005, USGAO 2007). There are great uncertainties about world oil reserves, technological capability to extract oil from the ground and ocean, capability to substitute other fossil fuel sources (coal, oil shale, oil sands) for oil, and development of alternative nonfossil fuel energy sources (wind, hydrogen, ethanol, nuclear, biomass). Other concerns relating to oil adequacy are potential disruptions in primary oil-producing regions from terrorists, political turmoil, hurricanes, and uncertainty about future world oil demand (USGAO 2007).

Although new energy sources are becoming available, worldwide oil demand is expected to grow at near 1.5 percent per year over the next 10 years based on projections from the International Energy Agency. Various energy alternatives, such as algae, hydrogen-fuel cells, nuclear power, and hybrid vehicles, have the potential to support oil as a primary energy source, but several years of development will be needed before their impact is significant. Renewable energy sources collectively may be able to provide 20-30 percent of the world's total energy needs by 2030 (Leeb 2009, Abraham 2010, Smith 2011). I refer the reader to Abraham (2010), Bryce (2010), Smith (2011), and Leeb (2009, 2011) for detailed analyses of the potential of renewable energy sources to replace fossil fuels. Recently Leeb (2009) has demonstrated that individual natural resource uses impact on one another in a series of vicious cycles that could shock complex civilization societies such as the United States and European Union. He provides clear examples of how development of alternative energy sources, such as wind power, can be limited by metals and how development of the tar sands in northern Alberta, Canada, require large amounts of water and natural gas (also scarce resources). He emphasizes that growing shortages of all commodities, including water, minerals, metals, and rare earth elements, not just oil, makes a shift to alternative energies much more difficult than our leaders seem to realize.

Nuclear power in combination with natural gas are considered by many energy experts to be the fuels of the future (Abraham 2010, Bryce 2010). This is because they have higher power density, relatively low cost, relatively low environmental impacts, and can potentially provide the tremendous quantities of energy needed to power the increasingly electronic world of today and tomorrow (Bryce 2010). Both nuclear power and natural gas have much lower air pollution than coal and oil. A common term used in describing the role of these two energy sources in the United States energy policy is N2N (Bryce 2010). Basically this involves using natural gas in the short term as a bridge to nuclear power in the long term.

World-wide nuclear power plants provide about 6% of the world's energy and about 14-15% of the world's electricity. The primary producers of nuclear power are the United States, France, and Japan. China is rapidly developing nuclear power.

The major cost in providing nuclear power involves the initial construction of the plants rather than the uranium used to fuel them. Presently, lack of uranium is not an important constraint on nuclear power development (Bryce 2010). World reserves of uranium are presently estimated to be adequate for 85 years but more will likely be found. The potential of nuclear power to provide an almost limitless source of energy was recognized in the 1950's.

There is little doubt that in the future nuclear power can deliver high amounts of electricity on a competitive basis with alternative sources. Bryce (2010) points that although nuclear power plants have high initial start up costs, they are no more costly than offshore wind but cheaper than solar. Coal and natural gas power plants are initially less costly than those for nuclear power but the long term operating costs are much higher. A major advantage of nuclear power over wind and solar is that it is constant rather than intermittent.

Nuclear power has some major environmental advantages over coal, natural gas, wind, solar power, and biomass. Bryce (2010) considers nuclear power the most green of our future energy alternatives. Two of the biggest advantages of nuclear power are that the land requirement for a nuclear power plant is very small as opposed to wind, solar, biomass or hydro power and atmospheric pollution is near zero. Wind power requires about 45 times as much land as nuclear power to produce a comparable amount of power (McDonald et al. 2009). For solar photovoltaic power, the land factor is 8 to 1 compared to nuclear power. Corn ethanol is the most land intensive of all energy alternatives with a rate of 144 to 1 compared to nuclear power. Wind power requires nearly 4 times more land than natural gas and 7 times more land than for coal for equivalent power (Bryce 2010). Large scale development of both wind and solar power will result in vast areas of rangeland landscapes cluttered with "energy sprawl" from wind turbines, solar panels, power lines, substations, and roads. Much of this land will be unsuited for other uses. Already there are growing protests to wind developments on both public and private lands in the United States. In addition to large land requirements, wind farms create noise pollution from huge turbine blades that can cause headaches, dizziness, and affect sleep. Bryce (2010) reviews this problem in some detail.

The major advantage nuclear power has over the fossil fuels is that it can produce high amounts of power with literally no atmosphere pollution from carbon dioxide and neurotoxins and other air contaminants. This can be done with high reliability and moderate cost. The primary problems confronting nuclear power are human safety and hazardous waste disposal.

Nuclear power may be the only alternative if the goal is to have abundant energy and control carbon emissions. Leading energy experts such as Bryce (2010) and Abraham (2010) emphasize we have come a long way in learning how to build and safely operate nuclear power plants. Basically, nuclear power plant disasters have resulted from human error and negligence. Nuclear power plant operators today are much better trained than 30 years ago and modern equipment is much less likely to malfunction. The Fukishima experience in Japan shows it is wise to avoid densely populated and earthquake prone areas when building nuclear power plants. The public must be prepared to accept some risk for the benefits of nuclear power. Theoretically, intensive development of nuclear power seems to provide the pathway for the world to have adequate electricity without atmospheric contamination or energy sprawl over vast rangeland landscapes.

Water Use and Global Warming

After oil, I consider scarcity of unpolluted fresh water the second biggest threat to world economic growth and capability to support more people. The problem of water crisis where the supply of water in a region exceeds its demand has been gradually increasing during the past 10 years (Brown 2008, 2011, Fishman 2011). A few high profile examples of recent water crises include Western Australia in 2009, Atlanta, Georgia in 2007, and Somalia in 2011. The primary problems related to fresh water scarcity are depletion of underground stores (aquifers) of water, melting of mountain glaciers due to global warming, possible increasing frequency and severity of drought due to global warming, and contamination of water supplies from human activities (Brown 2008, 2011, Fishman 2011).

The concept of peak water is starting to receive attention by both the scientific and news communities. Basically, peak water involves aquifers (both renewable and non-renewable) that are being depleted by human use rates that exceed natural recharge. Rivers, dams, and most lakes are renewable water sources that are recharged by mountain snow melt and natural rainfall. Global warming is disrupting the annual amounts and timing of these sources of water (Brown 2008, 2011; Fishman 2011).

A major part of the increased food production from the “green revolution” that has allowed the world human population to increase by 250% since 1950 is due to irrigation (Cribb 2010, Brown 2008, 2011). Food production requires high amounts of water. About 70% of the world’s fresh water consumption goes into irrigation (Cribb 2010). Industry and power generation account for 20% of water usage while the other 10% goes to domestic use in homes and other buildings. Urban use is rapidly increasing at the expense of agricultural water use as cities in various parts of the world expand. Cribb (2010) points out that irrigation has been used for at least 8,000 years. It is a cornerstone for civilizations to develop as it allows one person to feed many. City and industrial growth has depended on reducing the labor needed for farming. In arid and semiarid areas, irrigation greatly increases both amount and reliability of food production. Presently about 45% of world food comes from irrigation but in the future, this will need to be increased to 70% to feed 9-10 billion people in 2050. During the same time, the water available to meet this need is shrinking.

City growth, food demand growth, desertification, water contamination, and global warming all interact to deplete fresh water reserves and accentuate water scarcity. By some estimates, fresh water scarcity will affect 70 percent of the world's people by 2050 (Brown 2008, Cribb 2010, Fishman 2011). About 20 percent of the people could face life threatening water scarcity that will force major dislocations in where they live. This will put heavy immigration pressure on European, North American, and Scandanavian countries where fresh water supplies are more available (Brown 2008, Smith 2010).

Although major water scarcity problems occur in many parts of Africa, India, and throughout most of the Mideast, China is the country where water shortages will likely cause the most global upheaval (Brown 2008, Cribb 2010, Leeb 2011). This is because China is the world's most populous country and is rapidly developing its economy to become the world's biggest supplier of material goods. China is raising living standards for its people by a high level of exporting to others, especially the United States and European Union. Tremendous quantities of water will be needed in the future to meet China's domestic, agricultural, and industrial needs. China confronts accelerating water demand with shrinking supplies of both ground water and river flows (Brown 2008, Cribb 2010, Leeb 2011).

Over half of China's cities are now experiencing water shortages and most of the urban water is polluted. Water tables for several of China's largest cities (including Bejing) are rapidly falling (Brown 2008, Cribb 2010, Leeb 2011). In the heart of its primary corn and wheat production region, water tables have dropped precipitously over the last 20 years at several locations. Over the next 10 to 20 years, the problem of fresh water scarcity and contamination could completely derail China's transformation into the world's biggest industrial economy. Water problems could also cause destabilizing social and political unrest within China if solutions are not found.

India, the world's second most populated country, confronts water problems almost as daunting of China (Brown 2008). About 20 percent of India's irrigated farmlands are experiencing rapid drops in water tables. This is forcing many Indian farmers to abandon irrigation based on gasoline powered pumps and return to dryland farming.

In the United States, groundwater depletion threatens several cities and agricultural areas Brown 2008, Fishman 2011). The biggest concern is the drainage of the Ogallala aquifer, important to eight states in the American Central Great Plains as a source of irrigation water. The Ogallala aquifer accounts for 27% of the irrigated land in the United States. Sometime between 2030 and 2040, it is probable this aquifer will be nearly dry due to a depletion rate that is 10-12 times the rechargeable rate. Nebraska, Kansas and Texas will be more impacted than other states (South Dakota, Wyoming, Colorado, Oklahoma, New Mexico) where it occurs.

According to the Natural Resources Defense Council, 10 major U.S. cities face severe water shortages in the next 10 to 20 years. Criteria for this use include projected growth in human population, ground water availability, availability of alternative water resources, and susceptibility to drought.

Water conservation to reduce water usage does have a lot of potential to reduce water problems in the United States, Australia, and worldwide. Improved irrigation methods involving overhead sprinklers or drip irrigation are more efficient that traditional flood irrigation (still the most commonly used and oldest irrigation system) (Cribb 2010, Brown 2011). However, they are also much more costly. New technology for better measurement of crop needs for water coupled with improved irrigation techniques have potential to increase water efficiency. Various measures to improve irrigation efficiency are discussed in detail by Brown (2008) and Cribb (2010). Both authors make the point that low water productivity is often caused by low water prices due to government subsidies. Pricing water in accordance with supplies encourages all users to avoid wasteful practices and adopt the most efficient technologies.

Switching to more water efficient crops can increase water productivity in some agricultural situations (Cribb 2010). Rice production requires much higher water quantities than wheat production. China, India, and Egypt are examples of countries where wheat is replacing rice on farmlands where irrigation water is limited.

Various strategies are available to reduce water shortage problems such as desalinization of sea water. They also include development of drought resistance crops, development of salt-resistant crops, rain making, harvesting icebergs, improved irrigation methods, and long distance diversion and transport of water (Brown 2008, Cribb 2010). However, they all have drawbacks and cannot solve the world water problem without human population stabilization. (Holechek et al. 2003, Brown 2008, Cribb 2010).

Rangeland management practices that involve manipulation of shrub and tree cover to maximize water yields will likely receive greater emphasis in government policies in more developed western countries with large areas of arid and semi-arid rangelands such as the United States and Australia. In several developing African and Asian countries, there is great need for improved grazing management to reduce soil erosion and the associated problem of low water quality. Readers are referred to Valentine (1989), Heady and Child (1994), and Holechek et al. (2011) for detailed information on range management practices to increase water yield and quality.

Implications for Policy Development, Rangeland Management, and Ranchers

In this section I will first identify at the macro-economic level some of the problems along with changes that I believe will be necessary to sustain both humanity and rangelands. My key premise is that the welfare of humans and rangelands are tightly interlinked. In the second part of this section, I will focus on what I foresee as the challenges and opportunities that lie ahead for range livestock producers.

Macro-Economic Problems and Solutions

During the past 22 years since the fall of the Soviet Union, the United States has dominated the world as the sole super-power. The United States capitalistic model for economic development and trade has been adopted to varying degrees by almost every country in the world. This economic model as it relates to rangelands and ranchers is discussed in detail by Holechek et al. (2003, 2011). The basic problems with the world economy as it now exists are that it is based around sustained unbalanced trade with the developed western countries having chronic trade deficits and the Asian countries having chronic trade surpluses (Choate 2009, Casey 2012). It involves extreme globalization and specialization, and it depends heavily on increasing extraction of finite natural resources to accommodate ever more people with ever more material consumption (Kuntsler 2005, Brown 2008, Friedman 2008, Cribb 2010, Leeb 2011). The general objective of global macro-economic policy has been to provide the entire world population with a standard of living similar to that of the United States. The major flaw is that this goal is untenable due to finite natural resources (fossil fuels, water, farmland, phosphorus, various metals), and gradual degradation of essential ecosystem services. While the United States accounts for only 4.5 percent of the world's human population, it annually uses about 20 percent of the world's oil. By some estimates, if the rest of the world lived like Americans, 5 to 6 more planet earths would be needed to supply the basic resources. China with its 1.3 billion people is now embracing the American lifestyle which is accelerating demand for essential natural resources and intensifying pressures on ecosystem services (Friedman 2008, Leeb 2011). To further compound the problem of increased material consumption, an additional 77 million people are being added to world population every year.

The first obvious implication from a policy standpoint is to strengthen efforts to stabilize the world human population. Rather than explore this topic, I will refer the reader to Holechek et al. (2003), Friedman (2008), Cribb (2010), and Brown (2008, 2011) for human population management and stabilization strategies.

The second issue which is as important as population stabilization is to shift from the United States model of economic development that emphasizes high energy and material consumption to a model that meets basic human needs while sustaining natural resource supplies and ecosystem services. Here I refer the reader to Holechek et al. (2003), Friedman (2008), Rubin (2009), Steiner (2009), Bryce (2010), Cribb (2010) and Fishman (2011) for market oriented approaches to solving energy, food, water, and climatic instability problems that lie ahead.

As the world's largest economy, biggest consumer, and most formidable military power, it is my view that the United States should take the lead in sustainability through restructuring its own economy. By various measures, the United States has become the world's biggest debtor (total federal government debt is 16 trillion dollars) and is highly dependent on other countries for critical natural resources (Walker 2009, Ferrara 2011, Casey 2012). As an example, the United States imports over 50 percent of its oil. This is a major contributor to its massive trade deficits (over 500 billion dollars a year) and a big drag on its economic growth. Changing the tax system in the United States away from income taxes to consumption taxes, especially on fossil fuels, will be essential for the United States to solve serious problems relating to excessive fossil fuel use, urban sprawl, carbon emissions, trade deficits, and loss of industrial capability to other countries (Holechek et al., 2003, Choate 2009, Rubin 2009, Walker 2000).

Under the conditions of extreme globalization and specialization that now characterize the world economy, nearly all countries are vulnerable to shocks involving disruption of transport of energy, minerals, food, and basic goods (Leeb 2009, Rubin 2009). A continuing supply of cheap fossil fuel energy is required for the cargo ships and airplanes necessary for extremely globalized trade (Rubin 2009). Many countries have developed highly specialized economies that depend on supplying a particular country one or few resources (Casey 2012). Argentina now depends heavily on exporting soybeans to China while Australia depends heavily on exporting minerals to China. Conversely, China depends heavily on exporting manufactured goods to the United States and

European Union. If one major country (United States, China, or the European Union) severely falters, it can take down the whole world economy. There is growing concern and evidence that China's growth rate of 8 percent for the past 20 years cannot be sustained (Richards 2011, Casey 2012). China may have greatly overbuilt its infrastructure and housing using excessive debt as was done by Japan in the late 1980's and the United States in the early 2000's. There is the strong possibility that China's economy is a bubble ready to pop. If this happens, it could throw the entire world into deep depression and cause major social upheaval in many countries including China itself. With impending peak oil, uncertainty regarding China's economy, and extreme debt levels in the United States and Europe, it seems that movement towards balanced trade, economic diversification, and local self sufficiency are wise counter strategies to the high risk globalized economy so dependent on China.

Policies for Rangelands

In my view, the biggest current rangeland problem in the United States has been the squandering of the land base through poorly regulated real estate development (Holechek 2006, Holechek et al. 2011). This has not only shrunk and fragmented some of the nation's most productive rangelands but has also resulted in a colossal real estate bust and extended economic downturn. Although the losses of grazing capacity and ecosystem services are significant, the more subtle, bigger problem is that the extreme sprawl that has occurred over the past 30 years has greatly increased fossil fuel use and dependency, the need for more and expanded highways, air contamination with greenhouse gases, and the amount of time people spend in travel to meet daily needs (Kuntsler 2005, Holechek et al. 2003, Holechek 2006, Rubin 2009). The type of rangeland development that has occurred in the United States now makes it much more expensive and difficult to cope with rising oil prices and carbon emissions by implementing alternative mass transportation systems to private automobile traveling. Abandonment of housing due to foreclosure and high living costs in urban peripheral and exurban areas is a growing problem. I believe that poorly planned and regulated rangeland development may also be a problem in Australia. European countries such as the United Kingdom and Germany provide examples of how development can be managed to minimize loss of agricultural lands and encourage mass transportation (bus, train, subway) (Holechek et al. 2003, Holechek et al. 2006, Rubin 2009, Steiner 2009).

Regarding the impending challenge ranchers confront of providing more meat for an expanding world population, I refer the reader to previous papers I have written for detailed information in terms of policy implications (Holechek and Hawkes 2007, Holechek 2007, Holechek 2009, Holechek et al. 2011). In summary, I believe it is prudent for countries with significant rangeland resources (United States and Australia) to heavily invest in their conservation and enhancement to meet future food needs, diversify their economies, enhance ecosystem services, improve their trade balance, reduce energy dependence on other countries, and mitigate global warming. A wide variety of macro- and micro-strategies will be needed to accomplish this. At the macro-level, these include energy conservation, lifestyle changes, development of alternative energy sources, modification of transportation systems, and modification of food production systems. At the micro-level, policies that encourage sound grazing management, noxious plant control, fire management, drought planning, and animal husbandry are suggested. The benefits of these policies will be a stronger more diversified economy, more self-sufficient communities, increased food security, increased employment, and improved ecosystem services.

Strategies for Range Livestock Producers

I expect global meat prices to rapidly increase over the next decade but at the same time ranching costs will move upward. Therefore it will be a very challenging time for range livestock producers. Ranching risks defined by Holechek et al. (2011) fall into basic categories of climatic, biological, financial and political. Management of these risks may be much more important to rancher success than their capability to increase output of livestock products in response to rising demand. Typically, risks intertwine as drought periods are often coupled with falling local livestock prices due to herd liquidation in response to lack of forage (Holechek, 1996a,b). When ranchers attempt to restock after the drought ends, the biological risk of disease infecting their livestock is increased if they must purchase livestock from outside sources. Global warming has the potential to make annual precipitation more erratic but information is presently lacking on the magnitude of this problem on most rangelands.

I believe range livestock producers over the next 10 years will likely confront unstable financial conditions somewhat like those in the 1970's described by Holechek et al. (1994). The 1970's were characterized by alternating periods of inflation and deflation tied to market forces and government policies responding to rising debt, rising energy (oil) prices, and rising inflation. Although livestock prices were generally trending up, periodic short term cattle price downturns coupled with rising costs and interest rates were devastating to many heavily leveraged ranchers. In the Southwestern United States, low input ranchers who practiced conservative stocking and minimized debt were the most successful in terms of consistent profitability and surviving the 1980's deflation that followed the 1970's inflation (Holechek et al. 1994, Holechek et al. 2011).

Proper stocking is essential to profitable range livestock production and sustaining forage resources. Reliable procedure for setting stocking rates have been developed and evaluated by Holechek (1988), Holechek and Pieper (1992), and Galt et al. (2000). The biggest decision regarding setting of stocking rate is the harvest coefficient. Various rangeland researchers (Lacey et al., 1994; Johnson et al. 1996, White and McGinty, 1997, Galt et al. 2000, Smart et al. 2010) have recommended that a 25 percent harvest coefficient be used when forage is allocated to livestock in stocking-rate decisions. It allows both forage species and livestock to maximize their productivity, allows for error in forage production estimates, greatly reduces problems from buying and selling livestock, reduces the risk of financial ruin during drought years, and promotes multiple-use values. My observations over the past 20 years on various Southwestern U.S. rangelands have shown that a 25 percent harvest coefficient typically results in utilization levels of 31 to 45 percent.

The real problem is that few ranchers have the skills or time/labor resources to annually quantify forage production (Galt et al. 2000). Unless this is done, use of harvest coefficients higher than 25 percent invariably leads to land degradation and severe financial loses when drought occurs because of rancher reluctance to destock. This is especially true in arid and semiarid environments where forage production can vary by 50 percent or more from year to year. These losses can quickly eliminate any accumulated benefits of more-efficient forage use. Unused forage in wet years provides a reserve of forage for drought and increases plant vigor and soil water infiltration (Molinar et al. 2001). Rather than a waste, it is an investment in the future.

Various stocking rate studies reviewed by Holechek et al. (1999) showed small financial advantage of light stocking compared to moderate stocking on arid and semiarid rangelands. Across all studies, moderate stocking gave 31 percent higher financial returns than heavy stocking but only 11 percent higher financial returns than light stocking. These studies indicated that forage use levels of 31 to 45 percent typically obtained using a 25 percent harvest coefficient will maximize long term financial returns particularly if a few drought years occur. Further, over time this level of stocking allows ecological condition and grazing capacity to increase on most rangelands.

It is believed that one consequence of global warming will be much more erratic annual precipitation on rangelands throughout the world (Brown and Thorpe 2008, Hoffman and Vogel 2008). Even on the more humid rangelands, range livestock producers may have to cope with big swings in precipitation and forage production from year to year under these conditions. It is advantageous for ranchers to stock at light-to-conservative rates to avoid herd liquidations in drought years. Replacing a herd of experienced and well-adapted livestock on a particular ranch is nearly impossible without great expense and several years of time. Cattle herd productivity gradually increased over a 10-year period on a 1, 400-animal-unit ranch in western New Mexico when all new cattle were placed on the ranch after severe drought coupled with heavy stocking forced complete herd liquidation (Holechek et al. 2011). Calf crops were initially 58 percent and calf weaning weights were 170 kg with the assortment of cattle from different sources initially placed on the ranch. After 10 years of careful livestock culling, replacement, and adaptation, calf crops gradually rose to 91 percent and calf weights to 265 kg. Death losses were reduced from 8 percent to 2 percent over the 10-year period. Throughout this period, grazing intensities on the ranch were light to conservative and sound breeding and supplemental feed programs were applied. Provenza (2003) provides various examples that support the importance of adapted and experienced livestock to successful ranching.

Ranchers basically fall into categories of passive, moderately active, and highly active when it comes to implementing grazing management. All three styles can be successful if used correctly. In general, I recommend passive ranchers apply light stocking rates, using highly adapted livestock, and use manipulation of access to watering points as their primary means of controlling intensity, timing, and distribution of grazing across their ranches.

Many of the ideas advanced by Savory (1999) regarding the rotation of livestock on rangelands can work well for highly active ranchers particularly under conditions of herding rather than fencing. Holechek et al. (2011) points out an important drawback of short duration grazing (an early form of Savory grazing) can be the high fence costs particularly in arid areas. One of the big advantages of skilled herding using the Savory approach is that portions of a ranch or rangeland unit with higher forage production due to more rainfall, better soils, or past light use can be grazed more intensively when the forage is most palatable and nutritious while areas of low forage production can be rested, deferred, or lightly grazed. The use of skilled herders to control timing, intensity, and location of grazing under open range conditions is the most active form of grazing possible. However, the big drawbacks in the U.S. have been both the high cost and low availability of skilled herders. A moribund U.S. economy confronted with rising energy costs, overwhelming debt, and rising food costs could change this situation (Roubini and Mihm, 2010). Many ranch owners might find herding of their livestock a much more lucrative activity than other management alternatives.

Some range livestock producers will prefer a moderately active grazing management approach without intensive herding, particularly if their ranch is already partitioned into 4 to 6 pastures. A grazing strategy called multiple herd-variable stocking, described by Holechek and Galt (2004), merits their consideration. Excellent results occurred with this approach for both vegetation and livestock on New Mexico ranches where it was applied (Holechek and Galt 2004). Under this strategy, variable grazing intensity levels, multiple herds of livestock, and pasture deferment or rest are integrated into a unified system. Pastures with low forage production due to drought or excessive grazing are targeted for light use while pastures with high forage production are targeted for moderate use. Upland pastures with a high component of palatable shrubs are targeted for dormant season use, while lowland pastures dominated by forbs and perennial grasses are targeted for periods of active forage growth. Monitoring and drought planning are an important part of this strategy (Holechek and Galt 2004).

References

Abraham, S. 2010. Lights Out. (St. Martin's Press: New York).

Brown, L. R. 2008. Plan B 3.0: Mobilizing to Save Civilization. (W. W. Norton and Company: New York).

Brown, L. R. 2011. World on the Edge. (W. W. Norton and Company: New York).

Brown, J. R., Thorpe, J. 2008. Climate change and rangelands:Responding rationally to uncertainty. Rangelands 30(3):3-7.

Bryce, R. 2010. Power Hungry (Public Affairs Books: New York).

Casey, M. J. 2012. The Unfair Trade. (Crown Business: New York).

Choate, P. 2009. Saving Capitalism. (Vintage Books: New York).

Cribb, J. 2010. The Coming Famine. (University of California Press, LTD.: London).

Ferrara, P. 2011. America's Ticking Bankruptcy Bomb. (Harper Collins Books: New York).

Fishman, C. 2011. The Big Thirst. (Free Press: New York).

Friedman, T. L. 2008. Hot, Flat and Crowded. (Farrar, Straus and Giroux: New York).

Galt, D., Molinar, F., Navarro, J., Joseph, J., Holechek, J. 2000. Grazing capacity and stocking rate. Rangelands 22(6):7-11.

Heinberg, R. H. 2005. The Party's Over. 2nd Ed. (New Society Publishers: Canada).

Hoffman, M. T., Vogel, C. 2008. Climate change impacts on African rangelands. Rangelands 30(3):12-18.

Holechek, J. L. 1988. An approach for setting the stocking rate. Rangelands 10(1):10-14.

Holechek, J. L. 1996a. Drought and low cattle prices: Hardship for New Mexico ranchers. Rangelands 18(1):11-13.

Holechek, J. L. 1996b. Drought in New Mexico: Prospects and management. Rangelands 18(1):225-227.

Holechek, J. L. 2006. Changing western landscapes, debt, and oil: A perspective. Rangelands 28(4):28-32.

Holechek, J. L. 2007. Rangelands and national security. Rangelands 29(5):33-38.

Holechek, J. L. 2009. Range livestock production, food, and the future: A perspective. Rangelands 31(6):20-25.

Holechek, J. L., Galt, D. 2004. A new approach to grazing management: Using multi-herd/variable stocking. Rangelands 26(3):15-18.

Holechek, J. L., Gomez, H., Molinar, F., Galt, D. 1999. Grazing studies: What we've learned. Rangelands 21(2):12-16.

Holechek, J. L., Hawkes, J. 2007. Western ranching, trade policies, and peak oil. Rangelands 29(5):28-32.

Holechek, J. L., Hawkes, J., Darden, T. 1994. Macroeconomics and cattle ranching. Rangelands 16(3):118-123.

Holechek, J. L., Pieper, R. D. 1992. Estimation of stocking rate on New Mexico rangeland. J. Soil and Water Conserv. 47:116-119.

Holechek, J. L., Cole, R. A., Fisher, J. T., Valdez, R. 2003. Natural Resources: Ecology, Economics and Policy. (Prentice Hall: Upper Saddle River, NJ).

Holechek, J. L., Pieper, R. D., Herbel, C. H. 2011. Range Management: Principles and Practices. 6th Ed. (Pearson Education, Inc.: New York).

Johnston, P. W., McKeon, G. M., Day, K. A. 1996. Objective use of grazing capacities for southwest Queensland, Australia: Development of a model for individual properties. Rangelands 18(2):244-258.

Kuntsler, J. H. 2005. The Long Emergency. (Grove Press: New York).

Lacey, J., Williams, E., Rolleri, J., Marlow, C. 1994. A guide for planning, analyzing, and balancing forage supplies with livestock demand. Montana State Univ. Ext. Serv. Publ. E13-101.

Leeb, S. 2009. Game Over. (Business Plus: New York).

Leeb, S. 2011. Red Alert. (Hatchette Book Group: New York).

McDonald, R. R., Fargione, J., Kiesecker, J., Miller, W. M, Powell, J. 2009. Energy sprawl or energy efficiency: Climate policy impacts on natural habitat for United States of America. (The Nature Conservancy: Arlington, VA).

Molinar, F., Galt, D., Holechek, J. 2001. Managing for mulch. Rangelands 23(4):3-7.

Pfieffer, D. A. 2006. Eating Fossil Fuels. (New Society Publishers: Gabriola Island, British Columbia, Canada).

Pimentel, D., Giampietro, M. 2004. Food, land, population and the U. S. economy. (Carrying Capacity Network: Washington, D.C.).

Provenza, F. D. 2003. Foraging behavior: Managing to survive in a world of change. (Utah State University: Logan, UT).

Richards, J. 2011. Currency Wars. (Penguin Group: New York).

Roubini, N., Mihm, S. 2010. Crisis Economics. (The Penguin Press: New York).

Rubin, J. 2009. Why Your World is About to Get a Whole Lot Smaller. (Random House: New York).

Savory, A. 1999. Holistic Management. (Island Press: Washington, D.C.).

Simmons, M. R. 2005. Twilight in the Desert. (John Wiley & Sons, Inc.: New York).

Smart, A. J., Derner, J. D., Hendrickson, J. R., Gillen, R. L., Dunn, B. H., Mousel, E. M., Johnson, P. S., Gates, R. N., Sedivec, K. K., Harmoney, K. R., Volesky, J. D., Olson, K. C. 2010. Effects of grazing pressure on efficiency of grazing on North American Great Plains Rangeland. Range. Ecol. Manage. 63:397-406.

Smith, L. C. 2010. The World in 2050. (Penguin Group, Inc.: New York).

Steiner, C. 2009. $20 Per Gallon. (Grand Central Publishing: New York).

Tertzakian, P. 2006. A Thousand Barrels A Second. (McGraw-Hill: New York).

United States Department of Commerce (USDC). 2011. Statistical abstract of the United States. 130th Ed. (U. S. Department of Commerce, Bureau of Census: Washington, D. C.).

United States Government Accounting Office (GAO). 2007. Crude oil: Uncertainty about future oil supply makes it important to develop a strategy for addressing a peak and decline in oil production. GAO Dep. 07-283. (Government Accountability Office: Washington, D. C.)

Walker, D. M. 2009. Comeback America. (Random House: New York).

White, L. D., McGinty, A. 1997. Stocking rate decisions: Key to successful ranching. Texas A&M University Res. Ext. Serv. Publ. B-5036.