

A PROSPEROUS WAY DOWN

Elisabeth C. Odum
Professor Emerita, Santa Fe College
Gainesville, Florida

INTRODUCTION

This paper is based on one of H. T. Odum's special projects: the future of human civilization. He put together facts, explanations and predictions in many papers and the book we wrote together, *A Prosperous Way Down* (Odum and Odum, 2001). Instead of anticipating a crash, a possible, hopeful, view of the future is predicted. These discussions and conclusions are based on two hypotheses. The first, with which most scientists agree, is that we (the world and our economy) are going down (there will be fewer resources to live on). The second, less considered, is that the lower energy future can be prosperous and happy – depending on our human actions. Our plans and activities must include the world environment as well as the economy, as shown in Figure 1.

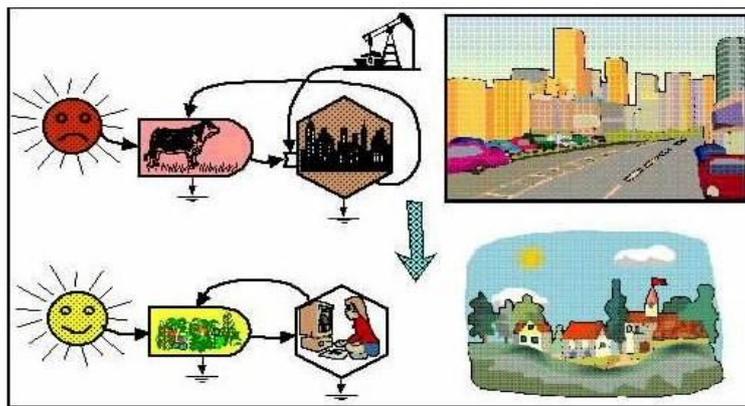


Figure 1. This picture of the trend illustrates the hypothesis with two parts: we are going to live with fewer resources and we can be prosperous and happy with fewer resources.

ENERGY RESOURCES

Our economy is based on fuels and we are using them up faster than the earth is making them. Figure 2 shows the Campbell summary graph of oil production - from the Gas and Oil Industry report (Campbell, 1997).

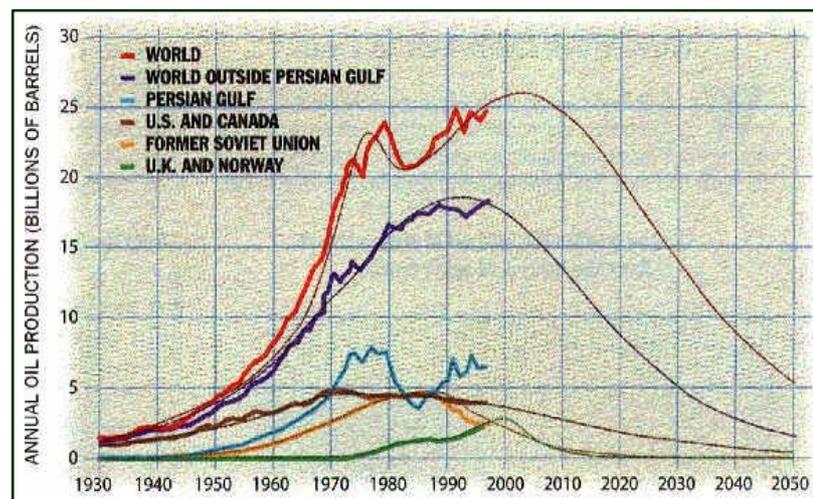


Figure 2. This graph from a Gas and Oil Industry report shows world oil production peaked in about 2004.

Another interesting graph from a later Campbell paper (Campbell, 2002) calculates our use of already-discovered fuels, contrasted to our projected demand.

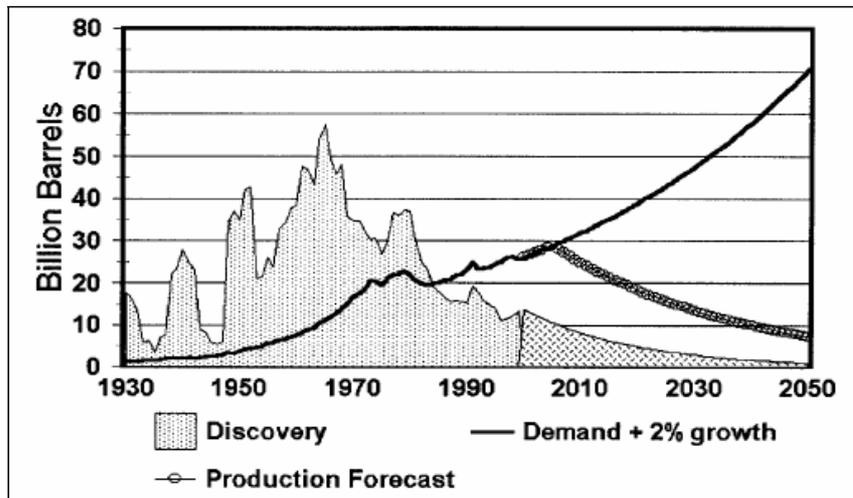


Figure 3. Discovery trend. Oil discovery peaked in the 1960's, when we were finding more than we used. Now, the situation is reversed, meaning that the historic trend of growth of about 2% a year cannot be maintained as we consume our inheritance from past discovery.

An important part of the scenario is that there are no new energy sources with as much power as fossil fuels. Table 1 is a short summary of the proposed alternative energy sources and their possible uses. None of them can take the place of fossil fuels.

Table 1. Review of alternate energy sources.

Nuclear fusion	It is the process of burning hydrogen, as on the sun. It would be like having the sun on earth, too hot to be cooled enough for humans to use it.
Nuclear fission	The supply of U235 may run out before fossil fuels, although its use can be extended by breeder plants. One of its problems is that Plutonium, a byproduct, can be used for making bombs and is very lethal. Another unsolved problem is the disposal of radioactive wastes.
Solar voltaic cells	Experiments show that the photovoltaic systems have a net emergy of about 2/1. They produce electricity for about 2% of American use. There more energy in materials than the electricity they produce.
Wind	Wind is a net source in areas with strong steady winds. The more equipment and computing needed, the less net electricity is produced.
Biomass	Wood and plants cannot be used extensively to produce electricity in the long run, since they will be needed for food, shelter and clothing.
Hydro-electricity	In mountainous areas hydroelectricity is a net source, but almost all the rivers have already been dammed.
Hydrogen	Hydrogen to use in fuel cells is proposed. But since it takes more fuel to make the electricity needed to break up the water or methane into hydrogen than the hydrogen produces, it is not a net energy or economic source.

Human civilization lives on two kinds of energy sources: renewable, like sun, wind, rain, tides, and nonrenewable, like fossil fuels, uranium, and copper. The computer model in Figure 4 shows the use of these sources. When this program is run, it produces the graph in Figure 5.

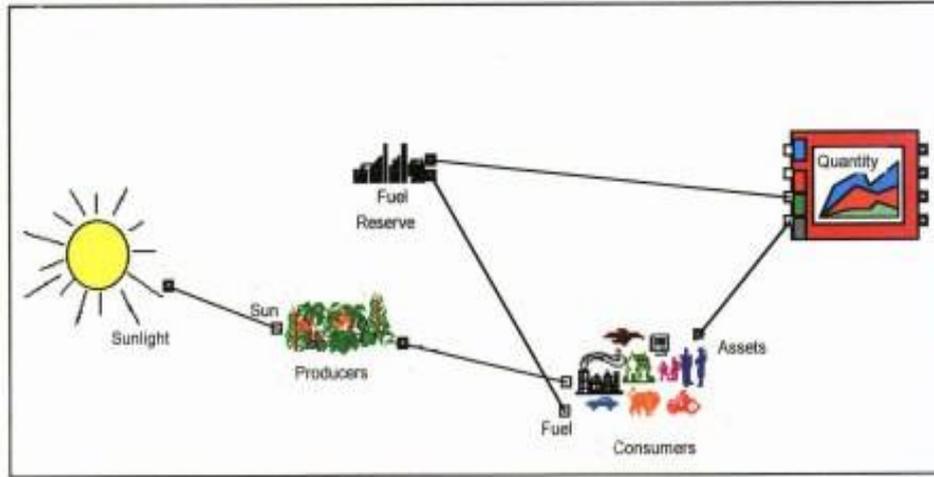


Figure 4. A computer model of the economy showing economic consumers using the two kinds of energy source renewables (sunlight) and nonrenewables (fuel).

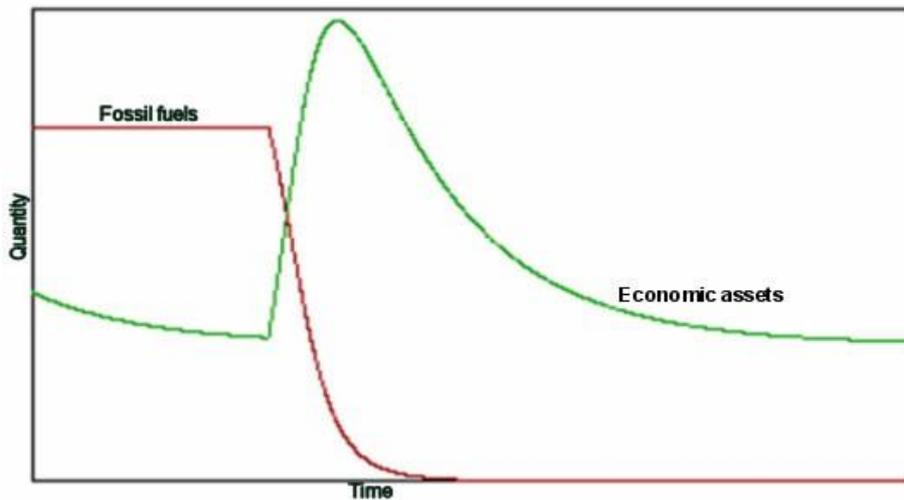


Figure 5. Before fossil fuels were used, the economy was supported by the renewable sources. When fossil fuels began to be used, economic assets grew rapidly. As fuels are used up, economic assets will again be supported by the renewable energy sources.

Two questions are asked. Where are we on this graph? Using predictions in Figure 1, we are near the top or just to its right. A harder question is how we can make the coming down slow and smooth and prosperous, or will we crash by ignoring predictions and continuing the fast life of super jets, oversized cars and vans. We believe people's behavior can be changed by learning new ideas.

To understand where we are at present, we need to consider the proportion of renewable to nonrenewable resources. The world is running on 60% nonrenewables, the U.S. 75%. Renewables will be maintained, but we will have to start using less nonrenewables. To keep the same standard of living, since nonrenewables are being used up, we either reduce the use of nonrenewables or reduce the population, probably a combination.

EMERGY PRINCIPLES FOR EVALUATIONS AND CALCULATIONS

To measure these quantities such as various energies and materials, for comparison and to make choices, we have the special concept, emergy. Different energies and materials can be measured on the same scale using emergy calculations. The following is a basic explanation of emergy principles.

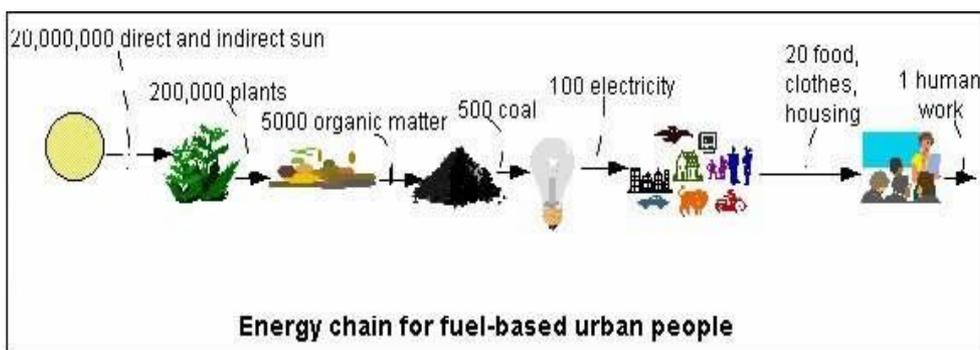


Figure 6. 20 million joules of direct and indirect sunlight are used to produce each part of this energy chain. 20 million joules is the solar energy of each component

This human energy food chain shows the joules in the units as they are processed from sun to electricity to human work. At each process some energy is used up, lost from the chain. The emergy of each unit is the amount of energy it took to make it: all of them used the whole 20 million joules of sunlight. For example, think of you, a human. If I put you in an oven, how much heat would I get out of you? That's your energy. But to evaluate the emergy of a human you count all the different kinds of energy taken to make him, from genetics, to tender loving care, to school, trips, everything that has gone in to make him. Your emergy is a much bigger quantity than your energy. UEV (energy unit value) is a related special concept. UEV is the amount of solar energy joules it takes to make 1 joule of a material or service. The abbreviation for solar energy joules is sej. Table 2 compares energy and emergy for quantities in the diagram in Figure 6.

Table 2. Comparison of energy, emergy and transformity for quantities in Figure 6.

	Sun	Electricity	Food, housing
Energy	20 E6 joules	100 joules	20 joules
Emergy	20 E6 sej	20 E6 sej	20 E6 sej

This is a hierarchical concept of value. Power and quality are different from physical quantity. This is a way to quantify the idea everyone has that the value of something is more than just the energy and materials in it. This does not represent the monetary value. Price is not its emergy value; price is just what someone would pay for it. Using emergy as the way of comparing different things on the same scale, its emergy value, we can calculate different choices.

MAXIMUM EMPOWER PRINCIPLE

The maximum power concept is a fundamental energy law, first suggested by Alfred Lotka in 1922.

In the self-organizational process, systems develop those parts, processes and relationships that capture the energy and use it with the best efficiency possible without reducing power.

Evolution is the same principle: organisms evolve to make the best use of their environment

CALCULATIONS OF EMERGY

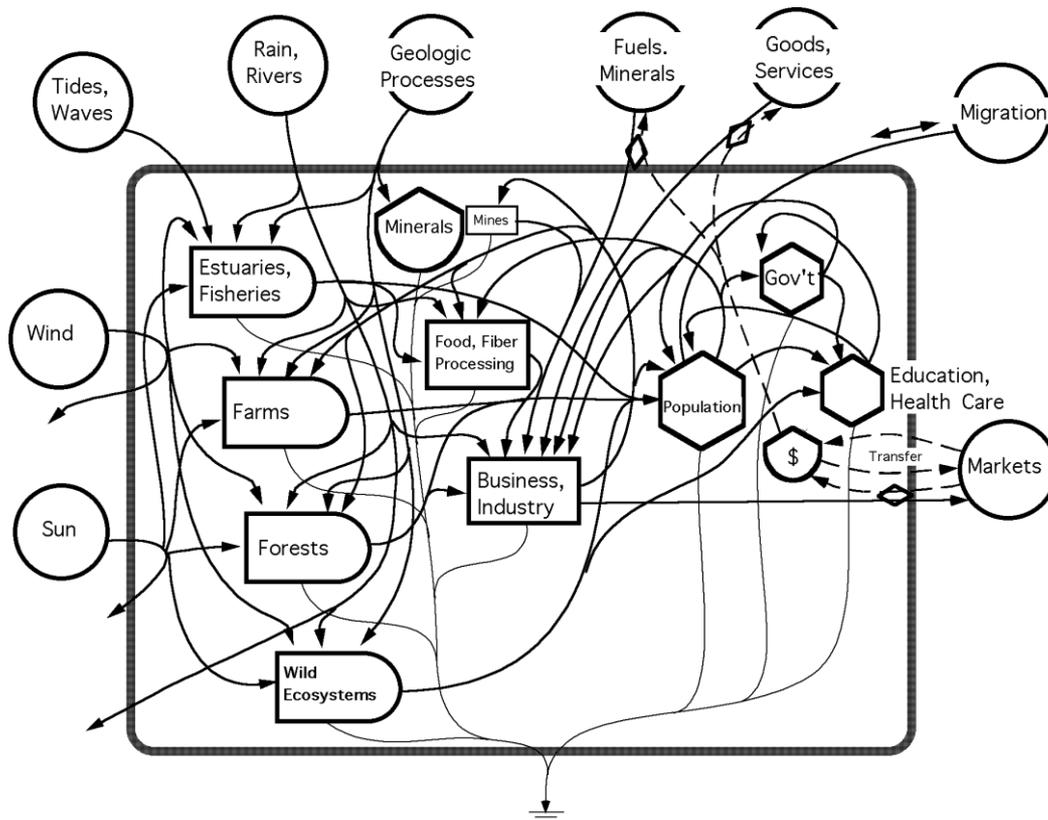


Figure 7. National emergy values are based on calculations of flows and storages in the systems.

Various problems the world is facing can be evaluated using emergy calculations. The purpose here is to use these calculations to make decisions as to how to keep the economy and environment prosperous as resources become more limited. Several international questions are studied. To answer basic questions about countries, the emergy use per year for each country is needed. The national diagram in Figure 7 is a general template used to start the research. To obtain the total emergy used in a country in a year there would be other particular items to be calculated.

IMMIGRATION AND EMIGRATION PROBLEMS

Over the world there is the problem of migration of people. They move for many reasons but the primary one is to find a better life, a higher standard of living. Since emergy includes all uses, it is a more accurate measure of standard of living than dollars. To calculate the emergy use per person per year, divide the total emergy use by the population. Table 4 shows the emergy use per person for the countries in Table 3. When all the flows and storages are calculated in original units, then multiplied by the sej/unit, the result is emergy in sej. The emergy use is dependent on renewable sources (size of country, sun and rain) and the nonrenewable sources (fuels and minerals) and imports. Recent calculations of emergy per country per year are summarized in Table 3. These quantities are very different from the countries' economic production since they include the natural resources.

Table 3. Comparisons of Yearly Energy Use of Nations.

Nation	E22 sej/year
USA	1150.0
China	917.0
Russia	703.0
India	522.0
Japan	360.0
United Kingdom	287.0
Brazil	277.0
Canada	268.0
Germany	153.0
France	144.0
Australia	138.0
Italy	126,5
Indonesia	125.0
Mexico	61,4
Saudi Arabia	55.8
Argentina	45.2
Chile	28.0
Austria	25.8
Switzerland	24.5
Denmark	17.8
Portugal	17.6
Paraguay	4.8

You can predict migration pressures by comparing the emergy per person for the different countries. For example, there is more migration from Mexico to the US, and from the U.S. to Australia and Canada than the other way. Emergy/person depends both on the emergy and the population. To lessen pressure for immigration and emigration we need more equity of emergy/person across the world

If we could equalize emergy/person that would that lessen the likelihood of war too. Isn't terrorism one way groups of people with low emergy/person feel they can affect the distribution of resources? Here's a local example: in your city unequal emergy/person encourages crime against property. The response is often a gated community to keep out people who want your resources.

Looking at the table there are two possibilities for reducing inequality between countries. Increase the emergy use by increasing production and reduce the population.

GLOBALIZATION: FREE TRADE

Emergy calculations can illustrate free trade and indicate some solutions to its problems.

Table 4. Comparison of Emergy Use Per Person Among Nations.

State or Nation	Emergy Use E22 sej/year	Population E6 people	Emergy Use/person E15 sej/year
Canada	268.0	30.5	87.0
Australia	138.0	19.4	71.0
United Kingdom	287.0	58.8	48.7
Russia	703.0	145.0	48.4
U.S.A.	1150.0	280.0	41.1
Switzerland	25.4	7.2	35.5
Japan	360.0	127.0	28.4
Chile	28.0	14.8	18.9
Saudi Arabia	55.8	22.0	25.4
France	144.0	59.8	24.1
Italy	126.5	57.5	22.0
Germany	153.0	83.0	18.4
Brazil	277.0	161.0	17.2
South Africa	73.9	43.2	17.1
Portugal	17.6	10.5	16.8
Argentina	45.2	35.1	12.9
Uruguay	3.1	3.2	9.6
India	266.0	1029.0	9.5
Paraguay	4.8	5.2	9.3
Mexico	61.4	76.8	8.0
China	917.0	1284.3	7.1
Indonesia	125.0	230.0	5.4
Bolivia	1.9	7.8	2.5

Table 4 shows the inequities in emergy use among countries. Since the Industrial Revolution, and even before, trade has usually moved resources from countries with natural resources to countries with industrialization. Much discussion is going on about globalization and whether free trade agreements are equitable. Will they help bring more emergy to the poorer countries?

Table 5 is a summary of the emergy per dollar of each country – how much emergy each dollar (internationalized) will buy in that country.

Table 5. Comparison of Emergy-Dollar Ratios Among Nations.

Nation	Emergy Use E22 sej/year	Gross Economic Product x E9 \$/year	Emergy/Dollar E12 sej/\$
China	917.0	979.9	9.35
Indonesia	125.0	145.0	8.60
Paraguay	4.8	6.3	7.68
India	266.0	442.0	6.03
Russia	703.0	1200.0	5.90
Chile	28.0	54.9	5.10
Brazil	277.0	58.0	4.80
Canada	268.0	599.0	4.50
Australia	138.0	340.0	4.05
Mexico	61.4	186.1	3.30
Bolivia	2.0	6.4	3.03
Uruguay	3.1	12.2	2.52
Saudi Arabia	55.8	241.0	2.30
United Kingdom	287.0	1390.0	2.06
Portugal	17.6	91.5	1.90
Argentina	45.2	297.7	1.52
Denmark	17.8	123.0	1.45
USA	1150.0	9940.0	1.16
France	144.0	1400.0	1.03
Switzerland	25.4	270.0	0.95
Japan	360.0	4500.0	0.80
Germany	153.0	209.0	0.73

The emergy-dollar ratio is the average amount of emergy that can be bought for one international dollar. It is calculated by dividing the country’s total emergy use by its GNP in international dollars. It is the buying power of the dollar in each country. Americans traveling in Brazil or China, get more for our money than we do at home. In France and Japan we pay more. When Brazilians or Chinese come to the US goods and services are more expensive. Figure 7 is a trade example which shows how emergy calculations can be used.

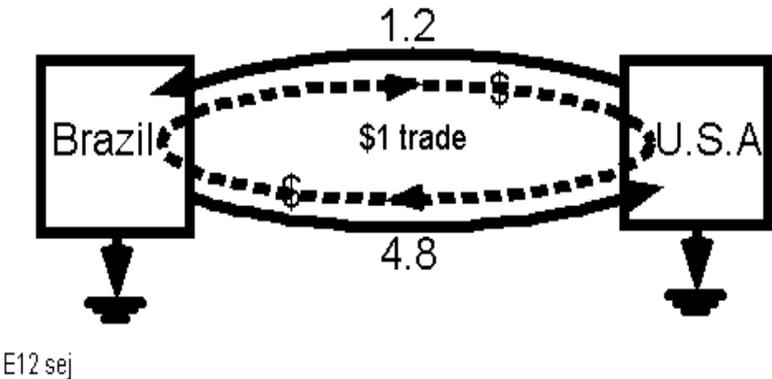


Figure 7. In an even dollar trade the USA can buy 4.8 E12 sej from Brazil; whereas Brazil can only buy 1.2 E12 sej from the USA.

On an even money basis this trade is equal and fair. But when looked at from an energy view, the USA is getting a four-fold advantage. So, until we can persuade national decision-makers to use energy trade calculations, countries should plan to trade with other countries that have similar or higher energy-\$ ratios. The way to bring equity to international trade is to base it on energy not dollars. Would this make the countries of the world less competitive – and more prosperous?

WAR AND SHARED INFORMATION

Many people believe that military fighting is sometimes necessary to solve international problems. Others believe that the power of non-violent action produces stronger and more lasting solutions. The systems ecology way to attack a problem like this is to look at the next larger system. If you look at the world of nations you see that information is more powerful than weapons and fighting. Information has the highest value, most energy, and greatest power. Shared information has even more power. In potential wars we can calculate how much energy power each country has and then predict who's going to win. Calculations like this should encourage the countries to make peaceful agreements.

For example, the USA had the power in WWII to win against Germany and Japan. However, in Vietnam we had less power and could not win so far away. Energy analysts could have calculated that, but we do not yet have the ear of enough policy makers.

We can consider the recent war in Iraq. There are probably several reasons the USA went into Iraq. We wanted control of the oil, and we also want to maintain political control of the basic resources of Middle East.

Many tried to settle the Iraq problem with shared information through discussion in the UN. But, the US leaders were too impatient. They believe military might is stronger than discussion and consensus. The US overwhelmed the Iraqis militarily, but it is doubtful that we won the peace. The information wars in Afghanistan, Iran, Syria and the other Middle Eastern countries will take much more positive shared information.

Shared information is spreading to cause changes in world views and actions. The 9-11 attack, the war in Iraq, disagreements with Pakistan, and terrorist actions are helping to make us aware of increasing envy of the wealthy. Information is also reinforcing the views of the poor that their situation is not fair, that there are great inequities in energy per person and maybe they can do something about it. Al-Jazeera TV in Qatar broadcasts the Eastern view; CNN shows the Western. We need both on all the TVs. The Internet World Wide Web is the way global information spreads everywhere. It is all over the world, even in countries which control their media.

As fossil fuels are used up, there is one optimistic possibility. With less fossil fuels we can produce less military hardware.

Two important subjects which need shared information to maximize power are energy equity, and religion. The goal of equity is a basic minimum energy for every person. Religious information is very high energy with much power. We must use shared information to discourage competition and create tolerance. Each person or group can have their own beliefs, but they must be accepting of others.



INSIGHTS FROM NATURAL ECOSYSTEMS

The present mature human economy is like the climax state of a mature ecosystem such as an old-growth forest. As it matures, a natural forest builds live and woody structure, increases biodiversity, carries on maintenance and replacement, and recycles materials for reuse. When the quantities and diversity in an ecosystem are as great as can be supported by the resources available, net growth has to stop. For a time the mature system's main product is maintenance. It replaces parts without any net increase. Human economies also tend to increase in quantity and complexity until they are using available resources as fast as they can be supplied.

For several centuries in the United States, agrarian colonial development by European-descended Americans used up soils and forests and moved west. The energy consumption shifted to fossil fuels. Resources were wastefully converted, and cities developed at a frantic pace, outdistancing many other economies. During growth, priorities expanded resource uses with the low efficiency and waste that accompany speed. Foreign resources were used more and more as the high-quality reserves in the United States dwindled. Growth slowed as fuel supplies and available water and land became limited. When growth decreases, traditional economic principles, predictions, and policies do not work well, and people may be ready for new policies.

CHANGES THAT ACCOMPANY DESCENT.

Patterns of human life may be expected to change during the time of descent as resources become scarce. Then prosperity will require improved efficiency for production of essentials and elimination of what is unimportant. Either we adapt with deliberate processes or have these changes forced on us with damaging repercussions. Although we can't predict how societies will react, we can use quantitative resource evaluations to characterize what is possible. For each of these new limits some suggestions are made that could make descent less traumatic and more prosperous.

Coming down doesn't mean going back to ways of the past. In general, descent means new ways. Within the time of one generation, we could observe a reversal of attitude so that descent becomes good and twentieth-century growth ideas become bad. As turndown progresses, people will see what works when resources are scarce. Many of the changes are already in progress.

POPULATION AND RELOCATION

Necessary Population Reduction:

To sustain a reasonable standard of living (energy per person), population has to be reduced at the same rate as the rate of resource use. Since population growth momentum may overshoot the time of descent, to sustain the energy per person requires rapid decrease in population. Either people reproduce less or are reduced by starvation and disease like that evident in Africa.

In most developed countries couples are limiting their families to one or two children. This decision is made by each family on the basis of the cost of raising and educating children. Multiplied by many families this decision adds up to a nation-wide reduction in reproduction. Populations in these developed countries would be decreasing except for immigration. In the underdeveloped world populations are still increasing. It has been found that the most effective population control in poorer nations is to give women the rights to property, employment, and the means to start their own small businesses. Birth control and early abortion are likely to become accepted.

Decrease in Urban Concentration:

The extreme concentration of economic enterprises and people in cities is based on cheap fossil fuels. Concentrations and populations are many times greater than can be supported by the surrounding landscape alone. As fuels become less available and cost more, cities have to diminish, eventually to the size compatible with their support area. Some industries are already moving to areas where there is more space, cleaner air and water, and land for workers' housing.

As fuels, electric power, goods, and services become more expensive, fewer people can commute. More clustered living will allow the development of more local social structure than is found in suburban housing scattered widely by community. The lower density of cities in a time of descent may make it easier to recycle dilute wastes through wetlands or into forests.

When there is less buying power for fuels and cars, people can be comfortable with small business jobs, living in apartment buildings of limited height close to a center without automobiles and parking lots. No-drive shopping and recreation zones can be established.

As city density decreases, there will be more space for trees, parks, and gardens. Greenery can be reestablished. Some concrete can be removed or perforated for water infiltration to assist the growth of larger trees; some can be covered with soil. Empty lots can be turned into playgrounds and neighborhood gardens, with plots for families to plant flowers or vegetables. Wetlands and floodplains can be restored for water quality and flood control.

To deal with the changes expected, the governments of cities and counties need to be combined so that an area and its population centers are managed and taxed as a single system. Private and public enterprises may develop that use the abandoned urban structure to reconstruct smaller less concentrated centers.

POLICY ON FUELS

Eliminating Wasteful Consumption without Reducing Empower:

To simply limit resource use is not a useful policy since it goes against the maximum empower principle of self-organization. But limiting luxury and wasteful uses, allows resources to go into productive functions and is adaptive. Thus, measures to limit unnecessary horsepower stimulate the economy; whereas, taxing or limiting useful resource uses is not a viable option.

Declining Dominance of Automobiles:

Rising fuel costs and general pressure for greater economic efficiency is likely to reorganize the automobile cultures of the developed nations. First there can be reduction of unnecessary horsepower, followed by reduction of autos. Private cars save individual time, but other measures can substitute including more use of communication in place of transportation, people moving closer to work, and more shopping on line.

Because higher costs of energy do cause people to eliminate some stupid waste, higher fuel taxes may be needed in the United States for wasteful uses, with exceptions for efficient use of fuels in agriculture, industry and essential family transport.

A way to eliminate waste is to require permits for cars with excess size and power and for other unproductive resource uses. However, eliminating waste with regulations requires a bureaucracy, which may have its own wastes, inefficiencies and corruption.

Bicycles, motorbikes, small cars, and buses can predominate since small size, efficiency of operation,

fuel efficiency and short trips allow energy to go for other essentials. Public transport can be straight, quick, and frequent if mostly on the main trunk lines and beltways. People can use smaller equipment such as bicycles, motorbikes, and minibuses to get from their houses to the main trunk lines. People living near centers will not need their own cars for daily life ...Bicycles will suffice if bikeways are given priority in the organization of roads.



Global Greenhouse Climate Changes:

There are current efforts now to reduce greenhouse gases that are changing the climate. Immediate ways to help without reducing economic activity include reducing private car horsepower in developed countries and pushing a global effort to reforest the depleted lands of undeveloped countries. As soon as global fuel consumption begins to decrease (as its scarcity and costs increase), the earth processes of carbon-dioxide uptake will start to restore a balance between carbon-dioxide release from fuel consumption and carbon-dioxide uptake by eutrophic plant photosynthesis, the carbonate buffer of the ocean, the alkaline soils, and the weathering of rock.

ENVIRONMENT AND AGRICULTURE

Increase of Lower Intensity Agriculture:

Rising fuel costs force agriculture toward a lower intensity with less technology, fertilizer and pesticide, and more labor. Labor can be provided by people leaving the cities where employment is decreasing. Diverse crop varieties that are more self-sustaining will have to be restored, even though their unit productivity may be less. In the rush to develop the high-intensity products (crops) with their excessive costs, many of the lower-yielding varieties—those that require less management, pesticide, fertilizer, and irrigation—have been discarded. Priorities are needed for agricultural experiment stations to identify intermediate-intensity varieties and supply recommendations for their use in intermediate-intensity agriculture. As the cities lose their buying power for luxuries, their people will depend on the rural basis of the region once again.

The money that farmers receive for their crop in competitive markets is only for the costs of human services that supply goods, services, and labor. Money from sales does not cover the work of the environment; yet, environmental processes are needed to maintain the natural assets of the farm. Subsidies—the feedback from consumer society to reinforce farms—are necessary to sustain agriculture. The idea is that money allows the farmer to manage the land to sustain yield. By using [agricultural] subsidies in place of excess production of one crop for export, farmers can diversify their products for domestic use.

As minerals become less available and more expensive, fertilizer prices will rise. When farmers can no longer afford to buy as much fertilizer, it will pay to use more natural ways to conserve the nutrients in the soil. More agricultural and urban nutrient wastes, manure and compost can be recycled into the soil.

Changed Role of Environment:

During the time of fossil fuel based growth, there was matching use of environmental resources, water diversion, soil loss in industrial agriculture and stripping of old growth forests. Overfishing, forest losses, and depleted soils are already widespread. As the use of fossil fuels decreases, the economy has

to shift once again to a smaller, agrarian base. However, during the transition and turn-down there could be frantic, competitive stripping of the environmental stocks needed for maximum production. To prevent collapse, demand on environment has to be reduced and reorganized during descent.

Soils and forests are renewable, but only with slower rotations than operated by our present economy. We can let fields go fallow for seasons, cut and replant forests on renewable cycles, and let swamps build peat and filter to sustain water quality. These are ways to keep slowly-renewable materials available.

INFORMATION AND ELECTRIC POWER

Peace and Maximum Empower by Global Sharing of Information.

When essential information is broadly shared on a large scale, it becomes long-lasting, a unifying mechanism. Information sharing can replace the restrictive information competition of growth capitalism. Television and the internet could change the global organization away from military territorialism. If global ethics for equitable trade and sharing information can prevail, global empower and peace can be protected by the information mutualism that maximizes empower. The dangerous alternative is fragmenting societies warring for residual resources.

Selected Saving of Civilized Culture:

Information seems ethereal and remote from biological and industrial processes. But because information requires many energy transformations, there are limits to the amount sustainable. Information capacity declines with diminishing resources. Also, information loses utility and retrievability as it accumulates. Like the brain, society has to select and condense the clutter of short term memory into fewer items of long term memory. The universities are the main institutions with this capability.

Priority Use of Hydroelectric Power:

To continue the essentials of the world's civilization requires that global information networks be sustained. But this requires a priority in allocating electric power at a time when electric power from fossil and nuclear fuels becomes more expensive. Strip-mining for coal will conflict with the need for agrarian production of food and fiber. It seems likely that centers of civilization will reorganize around the foot of mountains with hydroelectric power, thus using the high net emergy contributions of the earth. Full development of hydroelectric power reduces the food potentials of salmon and other migratory fisheries at a time when there may be human overpopulation and shortages of protein foods. One of our watershed evaluations found greater empower in a river's hydroelectricity than in its salmon runs. Since the prosperous way down depends on sharing a global information network, electricity must have high priority. The prosperous way down may well depend on society's ability to give priority to the greater need for geographic coherence of the larger scale.

CAPITALISM

Decrease in Growth Capitalism:

When there are resources and available loans, rapid competitive growth of a few enterprises prevails. A good new idea can start and grow rapidly. In ecosystems this is called eutrophic overgrowth by weeds. For example, when there are extra nutrients in a pond, water lettuce may spread over the whole pond, excluding other plants. In the economy, if an idea is successful, it will spread. This is growth capitalism. Those developments that started with investment loans outgrow those without the more rapid start. An example is the development of computers. Apple's Steve Jobs, created the first and it succeeded. Then, more other companies produced competing machines. As the market stabilized, fewer companies stayed in the market. Later, when there are few undeveloped resources, a no-growth system of higher diversity prevails because it is more efficient and better at recycling materials.

Descent Capitalism:

During descent new versions of capitalism may appear. Enterprises may be initiated to organize the contraction of the economy using the stored assets as the resource for organizing developing a smaller economy. There are already some specialists at downsizing. In analogous equivalents in ecosystems,

new generations are fueled with the storages of a previous annual cycle. A spirit of mutual helpfulness suitable for a mature [ecosystem wise] nation could replace the selfish competitiveness of the growth times now passing. To be prosperous, descent requires a reduced population, less money, and smaller salaries. Governments and banks will need to help finance initiatives for downsized redevelopment, but the economy will issue fewer stocks and bonds, borrow less, and develop lower interest rates. Beyond growth, cooperative competition replaces the destructive kind of competition to eliminate rivals.

Decrease in Unearned Income:

During growth, physical capital earns high interest as enterprises pay back loans and dividends. People who earned dividends may have large incomes for which they did no work for the system. After growth, when there are fewer investments, unearned income decreases. A no-growth system is more efficient if money is paid for real work.

Change in Development Policies:

When unused resources were available for development, laws developed that maximized competitive capitalism and growth (because monopolistic overgrowth maximizes empower at that stage of succession). Examples are sale and use of public lands for profit; priority rights for mining over use of surface land use; and corporations given the same constitutional rights as individuals to exploit economically. When there are fewer resources to exploit, such development-accelerating laws are likely to change. As efficiency becomes a recognized priority, measures to eliminate luxury and waste may be recognized in law and policy. For example, one proposal is to establish a limit to personal income at about \$150,000 per year for example. A policy suggested for downsizing reduces income of all personnel in place of the common practice now of reducing the number of employees.

Stock Market Transformation:

When most growth is over and the public realizes the fundamental change, a destructive stock market crash is possible. Some mechanism is needed to program a gradual, non-catastrophic deflation of the money held in stocks and bonds. For example, an economy-wide stepwise limitation of interest and dividend rates could shift money from stocks and bonds to ownership and efficient operation of those productive enterprises with good annual yields.

Private Enterprise with Public Control:

To maximize system prosperity, private production must include public benefit needs and external costs in its operation and pricing -not only make the most for the lowest cost to sell for the highest price. Private business can be required to add the costs of environmental protection and social equity costs of recycling materials, restoring land, and replacing destruction. Minimum wages and benefits need to be included in the costs. These costs are not a burden to an individual company if required of all competitors.

Profit and Non-Profit Enterprises:

Profits require expansion of resources and thus are appropriate during growth periods. Nonprofit enterprises are appropriate when growth is not possible. Profit and nonprofit enterprises can be public or private.

Developing Trade Equity:

Developing equity (equal energy in international exchanges) allows more countries to make maximum contribution to global empower. (Fig 7) Trade treaties can be used to adjust prices, subsidies, foreign aids, information and other types of exchange to be equal. We need to give priority to concepts of international respect and cooperation for global sharing.

More local production:

As the decreasing availability of fuels causes yields per acre to decrease, each country must again produce more of its own food. Good commodity policy keeps raw products for use within a nation. Home use policy lowers prices of food, housing, paper and fuel within the country and raises the

standard of living of consumers. Rising costs of fuels will reduce the international transport of bulky food. Energy that is saved can go for important needs. With less waste, exports are cheaper and compete better; wages buy more.

Insuring Full Employment and a Living Wage:

Whereas private enterprises during growth could absorb new workers, a mature nation without growth may need special mechanisms to sustain full employment. A solution to unemployment might be to restore permanently the program of public works that was successful in the Depression of the 30's. Jobs would be provided to all the unemployed at minimum wage with no time limit, although many would move on to higher paying jobs in the private sector. Jobs could include the environmental works in parks like that done by the old CCC (Civilian Conservation Corps), restoration of ghettos, aides to teachers, aides in hospitals and hospices, clerical aides in government offices, aids in research program and aides to the handicapped. In a nation without growth, some people may have to work at the minimum wage permanently. For national efficiency the question should be, "What minimum wage makes the individual self-supporting, capable of doing his or her part in each citizen's unpaid duties such as child rearing, maintaining satisfactory sanitation, and supporting the neighborhood?" Sustaining jobs against foreign competition depends on eliminating luxury and waste

Economic Enrichment by Reducing Consumption:

With less energy per person (less buying power), many people will have to reduce their consumption. Most will have to make difficult choices about what to do without. We need to develop economic incentives for reducing consumption.

Uniformly Reduced Salaries and Wages:

Perhaps the most important descent policy is 'cutting salaries uniformly'. Unions could help control necessary across-the-board wage cuts, thus increasing job security and continuing full employment. They can insist that downsizing cuts be at all levels of management as well.

International Minimum Wage:

To limit the way global capitalism can exploit labor by shifting operations from one country to another, we propose an international minimum energy wage, agreed to by treaty. Wage rates can be made similar by adjusting the minimum in each country to have the same real-wealth buying power. Instead of pulling down labor of developed countries, it will bring labor of underdeveloped areas up to a level that can sustain global production.

STRUCTURE AND MATERIALS

Replacing Flimsy Housing with Fewer Buildings of Quality:

In ecological succession where there are unused resources available, the initial structures are flimsy and temporary but effective at maximizing growth. Later they are replaced by larger, substantial, longer lasting, slow turnover assets. A similar evolution of buildings is expected and can be planned. Trailers and frame buildings with short life times will be replaced by those with substantial permanent structure and less maintenance cost, a process that is more advanced in Europe. As soon as populations decrease, there will be excess building space which can be converted into fewer, more permanent structures. Once society corrects the excessive salaries and unearned flow of money and energy to the rich, the housing industry can build smaller, more efficient units available to those with ordinary incomes. Personal living space will decrease. More people will live together in the older houses. Older, energy-saving architectural designs (such as passive solar technology) can be used that take advantage of nature, such as planting deciduous trees for summer shade and winter sun.

Reuse, Recycle of Materials, and Recycle to Ecosystems:

Efficient, maximum production requires that everything be reused or recycled (not accumulating in dumps). The kind of recycle of materials depends on the concentration and quality. The free market can deal with high quality and concentration, but the ecosystems are required for the low concentrations. To encourage conservation and reuse of materials, some manufacturers are being required to take back the materials they used in the packaging of their products. This plan saves

materials and reduces waste dumps. As resources decrease, reuse and recycling of materials will become more and more economical. A tax on packaging could help. Leaf fall and pruned or fallen limbs left dispersed on lands or in local compost piles—instead of concentrated by garbage trucks – can help to restore soils.

Communication Replacing Transportation:

We can save the resources and costs of transportation by using more email and phone mail in place of personal trips and standard mail. More jobs can be done on computers at home. These too have extensive energy requirements, but less than transportation with automobiles.

HUMAN LIFE

Minimum Standard of Living:

Systems principles suggest there is a natural hierarchy in the distribution of wealth that is functional. However, there is a minimum basic standard of food, shelter, education, health care and other necessities for each person to be productive.

Women ,Children, and Work:

During descent fewer children are needed. Women can have fewer children and more education for longer careers of productive employment. Some realities of the lower-energy world will be hard to accept, like not expecting your children to have a life richer in consumer goods than you have had. Children may live at home longer or move back home after having trouble getting started on their own. More people will be required to do the work that is now done by machines using fossil fuels. Societies making these changes promptly will prevail because of their greater efficiency.

Universal Baseline Health Care:

A new health care system is needed. A system that leaves millions uncovered with no health care insurance undermines national productivity. Adding profit to health care is an unnecessary diversion of energy. A health care solution that is consistent with hierarchical concepts and democracy is to set up a nonprofit health care system that provides some basics ‘for all citizens’ and includes pharmaceuticals, simpler operations, emergency treatments, pregnancy care and preventive medicine such as check-up examinations and vaccines.

Long hospitalizations and the more expensive, experimental, or luxury treatments could be omitted. These might be covered as now with private money and medical insurance. The old system may return in which diseases select survivors by testing vitality. Our humanitarian ethic may be revised to expect less health care.

Flexibility Regarding Sex:

The powerful sex drives of the human species are genetically inherited and thus not easily changed. However sex can be decoupled from reproduction and used more for satisfying the emotional needs for close personal relationships. The rigid mores channeling sex only into children are already being replaced with attitudes and laws that allow flexibility in sexual relationships and programs of birth control.

Education for the Future:

To prepare children for their lower energy future, we must describe and explain it to them. They need to know why it's happening and how they can fit into it. They will need to know how to manipulate information and computers. But they will also need experiences in practical living, such as how to grow edible food, how to repair rather than throw-away, and how to make housing more permanent.

A new course is needed that explains how the three E's are related: ‘energy, environment, and economics’. The course could use systems ideas, simple computer simulations, and energy concepts. Broad generalist training should also deal with the larger scale of environmental science and economy. In times of transition and descent, keeping job training up to date may be difficult. Part-time apprenticeship programs with local employers can help. In the absence of busing, new approaches are needed to foster diversity in the schools.

Progress in education may have to be made without much increase of budgets. Efficiency with fewer resources means reducing bureaucracy, reducing salaries of principals and superintendents, eliminating paperwork, cutting nonacademic activities, stopping outside interruptions and not tolerating misconduct. It need not mean increasing class sizes and conformity to central control. Efficient physical education means less expense on spectator sports and more participation by all students.

Family Values:

Some values and lifestyles have to change with the need for fewer children, decreased family resources, and fewer cars. Children continue to need stable family relationships. Communities can reorganize around smaller neighborhood schools. During descent, genetic families will need to be smaller. Thus other associations, such as relatives or friends living together may develop. For stability, the tax laws that benefit families with the orthodox lifestyle will need to be broadened to accept more options for organized relationships.

Religion:

The ethics of large scale unity needs to be added to the small scale ethics of traditional religions. Each person or group has his religious beliefs for his personal life. However, to maximize the power of the whole system of people – for us to live peacefully together - each person must be tolerant of others' beliefs. This is true for any belief or action that insists it is the only correct way.

Local Societies and Pluralism:

With less transportation there is opportunity for more social organization locally. The slogan is “Think globally; act locally. Developing more separate local cultures is not incompatible with global coherence providing all groups retain the ethic of global awareness, cooperation, and mutual respect.

Ideals for New Conditions:

During growth, many individuals seek money, political power, or celebrity. . But during descent and later, a different happiness principle is needed: An individual will feel a sense of worth by contributing to the larger system of environment and society.

The values for a growing economy are larger size, greater speed, and competition. Values for coming down are smaller size, efficiency, and cooperation. Faith that public good comes from individuals greedily seeking personal gain in a competitive marketplace should fade with the other ways that were useful for accelerating growth. If descent becomes a recognized mission by schools, churches, and families, these groups can help individuals find inner satisfaction in contributing to this common purpose. Within the time of one generation, we could observe a reversal of attitude so that descent becomes good and twentieth-century growth ideas become bad. The ‘growth is progress’ ethic of the industrially expanding world is being replaced now by ‘sustainability is good’ for a world that is no longer growing much. Next, as people learn to live with descent, the ideal will be ‘down is better’.

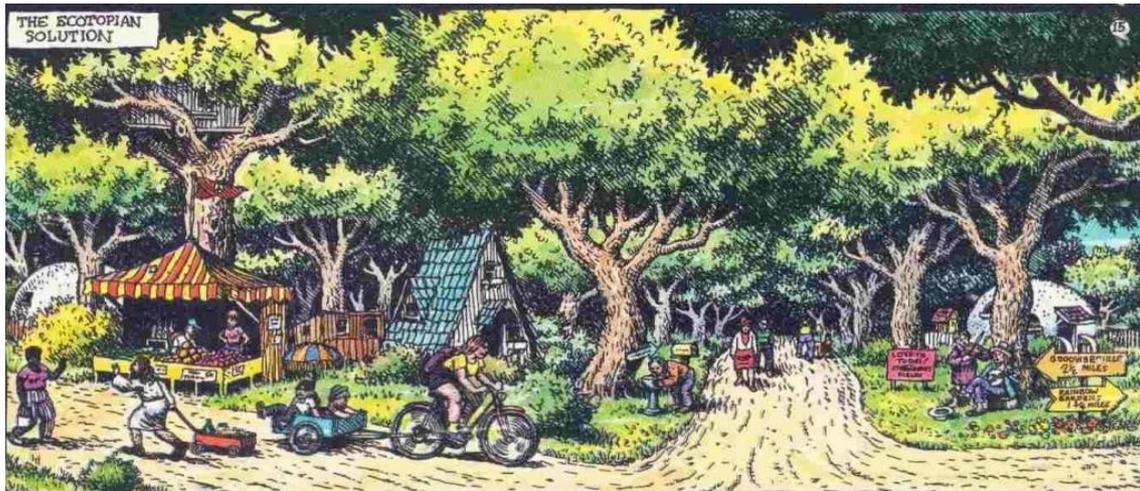
Efficient Lifestyle:

With more responsible attitudes that come from understanding how individual waste detracts from everyone's essentials, individuals can select a more efficient lifestyle. Society begins to admire those who own small cars and make them last. As cities decentralize into smaller communities, with jobs closer to home, there is an expectation that people will get to know their neighbors better and communities will become more cohesive. Assuming some success in reducing population, moderating income extremes, and restoring environmental life support, people can find interesting and meaningful lives without much reduction in real wealth per person. When there is less population and economic activity, times may be more tranquil.

We need to make beneficial descent the collective purpose for this century.

The revised American Dream:

We can look forward to a good living, a feeling of social justice, pleasure in doing a good job, progress in small steps, and satisfaction in seeing a few children grow (yours and others).



SUMMARY:

Principles that appear to govern all systems including human societies were used to consider the time of economic descent ahead. These include the energy law, the maximum empower principle, the universal energy hierarchy, the conservation and hierarchical distribution of materials, the spatial organization of centers, and the pulsing paradigm. We expect much of the culture and public policy appropriate for the growth period to be replaced with a new set of ethics and policies affecting each scale of time and space during descent. Decisive changes in attitudes and practices can divert a destructive collapse, leading instead to a prosperous way down.

GLOSSARY

Emergy: the available energy of one kind used up directly and indirectly to make a product.

Empower: energy per time

Maximum empower principle: systems develop to use the most emergy with efficiency. Cooperative competition or competitive cooperation: mild competition of individuals that benefit the whole group

NOTE

You can find more shared high quality information at the Center for Environmental Policy at the H.T. Odum Center for Wetlands, University of Florida, Gainesville, FL 30611.

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