Nov. 21, 2001

Ms Lisa Lewis,

Thanks for your assistance and encouragement in this little project — The presentation made at the AAAS Meeting in Omaha is somewhat reduced because of time limitations so doesn't contain as much information or as many pictures as I'd intended (In fact, I had to ad-lib quite a few more cuts from this copy — but at least, they didn't pull the plug on me.)

I made this up from my notes and edited in the pictures as presented - I hope somebody might be interested in it.

Yours Truly,

Ed Rogers

# The Tragedy of the Commons Revisited

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# The Tragedy of the Commons Revisited

"The wilderness and the solitary place shall be glad,
and the desert shall rejoice, and blossom as the rose!
"And in the wilderness shall waters break forth, and streams flow in the desert.
"And the parched land shall become a pool, and the thirsty land, streams of water!"

In these few lines, the poet clearly expresses our very strong emotional attachment to water, no doubt heightened by our realization that our existence depends on it.

Some 2200 years later, a professor from the university of Pennsylvania, Ian McHarg, finally added the necessary environmental caution, in a book entitled "Design with Nature" (1969, reprinted in 1994). McHarg insists that any design must incorporate all knowledge. Not only should it include all the scientific information about the area to be developed, but also social needs and historical factors, aesthetics, politics, etc. Of course, it's clear if you design within an area of parched land, you should not put in a pool, and in thirsty land you should avoid streams of water, however much they might appeal to your emotions. It is important to keep your emotions under the control of intellect, so you don't get carried away into self-destructive actions. Other writers have added their voices, for example Marc Reisner, in the book "Cadillac Desert"(1986), and Prof. E.O. Wilson, in his book "Consilience" (1998).

Starting within this framework, let's revisit Garrett Hardin. In his paper "The Tragedy of the Commons" (Science, vol. 162 (3859) p.1243 (1968)) he reminded us of the economic theory of Adam Smith, ("Wealth of Nations" (1776)): that the wealth of nations comes from the labor of the common man, and his use of his income according to his own selfish best interest moves his nation's economy forward to great success, as if by an "invisible hand." There are critiques of Smith's theorem that cast doubt on this sunny prediction. Hardin included one from a talk at Oxford in 1833 by William Forster Lloyd: the common man lacks long range vision so tends to destroy his environment, the "commons" that supports him. From this came Hardin's title The Tragedy of the Commons. Hardin also adds the caution that some problems do not have a technological solution. Overpopulation is one such: if growth rate is not addressed, any technological change that might lead to a slight gain in production will be used up in continued growth, merely increasing the number of people in abject poverty, with no improvement in the condition of any.

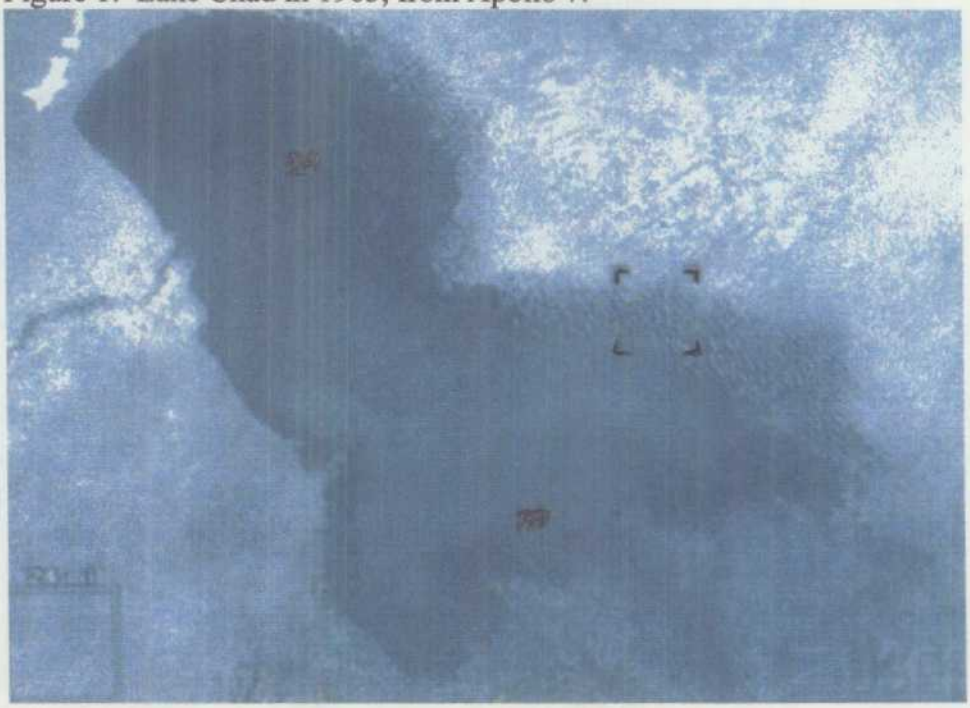
I feel it is a mistake to focus on the "common man" and on antique economic theory in attempting to evaluate the tragedies occurring around us. We need instead to see them in the context of McHarg's requirement that whatever we do must utilize all knowledge. Without that, actions by any group or leader, whether well meaning or not, will tend to lead to tragedy.

In my presentation, I will give examples of tragedies that continue to occur around us, because of the failure to use all knowledge. In some cases it almost seems there is an avoidance of <u>all</u> knowledge

Lake Chad

The four nations surrounding Lake Chad became independent as the culmination of long revolutionary battles, with the help of the United Nations' accord to end colonialism. At the time of Hardin's presentation, these countries (Chad, Niger, Nigeria, and Cameroon) had a total population estimated to be 65,000,000. An early photo from Apollo 7 shows that Lake Chad was already being impacted by overuse and was losing volume.

Figure 1: Lake Chad in 1963, from Apollo 7.



Note the Logone River emptying into Lake Chad from the west, and the Chari River from the south. In the northeast you can see a dry streambed that had not carried water into the lake for about 10 years because of the decrease in rainfall in the area to the north. The gray shading in the south half of the picture is savannah and woodlands, while the north half shows the paucity of plant cover in the Sahel.

In 1973, a second space shot showed the lake to be nearly split in two, at about half its original volume. (Figure 2.) Not until 1980 was the "Lake Chad Basin Commission" formed. The logo of this commission carries the outline of the historic Lake Chad, so they want us to assume their goal is to return the lake to that state. (Figure 3.) Continuing NASA "earthpix" show that by 1989 Lake Chad was reduced to less than 10% of its original size (Figure 4). Not until 1994 did the Lake Chad Basin Commission approve a "Master Plan for the Development and Environmentally Sound Management of the Natural Resources of the Lake Chad Conventional Basin." In addition to the loss of water volume, there is the even more serious problem of water quality, due to untreated sewage, fertilizer, pesticide and herbicide drainage into the shrinking lake, causing a great deal of illness. In contrast to the verbiage of the Lake Chad Basin Commission, the governments of the area are too weak and unstable to deal with these very difficult

Figure 2: Lake Chad in 1973, showing loss of volume.

**Figure 3: Logo of the Lake Chad Basin Commission**


problems. For example, the Nigerian government has distanced itself entirely, and transferred control to the state governments adjacent to the lake. This puts the power in the hands of local politicos, who focus on increased irrigation and farming within their area, from which they derive tax money, rather than addressing the needs of the lake. As a result the flow of the Logone River into Lake Chad has been decreased by about 70%, which will surely further deplete what little remains of the lake.

Figure 4: Lake Chad in 1989, showing 90%+ loss of volume.

At the same time as the decline in the lake's volume, and a major cause of the change, the population of the 4 countries has increased to about 155,000,000 people. This must be taken into account in any discussion of the future of the lake and its resources. Notice also the substantial loss of the savannah and woodland ecosystem south of the lake.

Of course many other factors apply. The repression of literacy by the colonial powers represented a serious drawback to the new nations formed in 1960. But their failure to improve literacy in the 40 years since then shows a great lack of leadership, and still acts as a strong block to any grass-roots changes. Continuing uprisings between factions attempting to gain power make strong action by any government very unlikely. Beneath this lies the crushing poverty among most of the population.

A monograph from African Accord Online under the heading "Water Wars" by Marie-Therese Sarch mentions philosophy. She rather dislikes Hardin's emphasis on limiting use, and would prefer to emphasize increase in efficiency, but it is clear from the pictures here that we are far beyond the point where a change in efficiency will solve the problems of the area. If we do get into such discussions, I could suggest inclusion of the philosophy of the lemming.

## Lake Victoria

The problems of Lake Victoria are not as critical as those of Lake Chad. It is farther south into the tropics, with substantial rainfall, and is fed by rivers from an 185,000 $km^2$ catchment. Its only exit is through the Owen Falls dam and hydroelectric plant, into the Blue Nile, so it has sufficient volume of water to meet present needs. However there is little long range planning as to how the lake should be maintained or protected. In 1947, the three countries surrounding Lake Victoria (Uganda, Tanzania, and Kenya) formed a

cooperative organization to manage the fisheries of the lake, which continued through several reincarnations, but not until 1994 did they begin to consider environmental issues instead of strictly commercial ones with the start of an "Environmental Management Program." Of course, during the strictly commercial early period, serious changes occurred in the lake. Foreign fish species were added, and native species declined with many now commercially extinct. The Species Survival Commission had hoped to make Lake Victoria a laboratory for the preservation of threatened species (the lake contains—or contained—500 species of freshwater fish, of which about 250 were found nowhere else) but now it is just a place to watch extinctions, in hopes of learning something of the causes. In spite of ecological concerns, Nile perch were smuggled in, and water hyacinths added by accident (legend has it that a lothario brought some in for his lady's garden pond.)

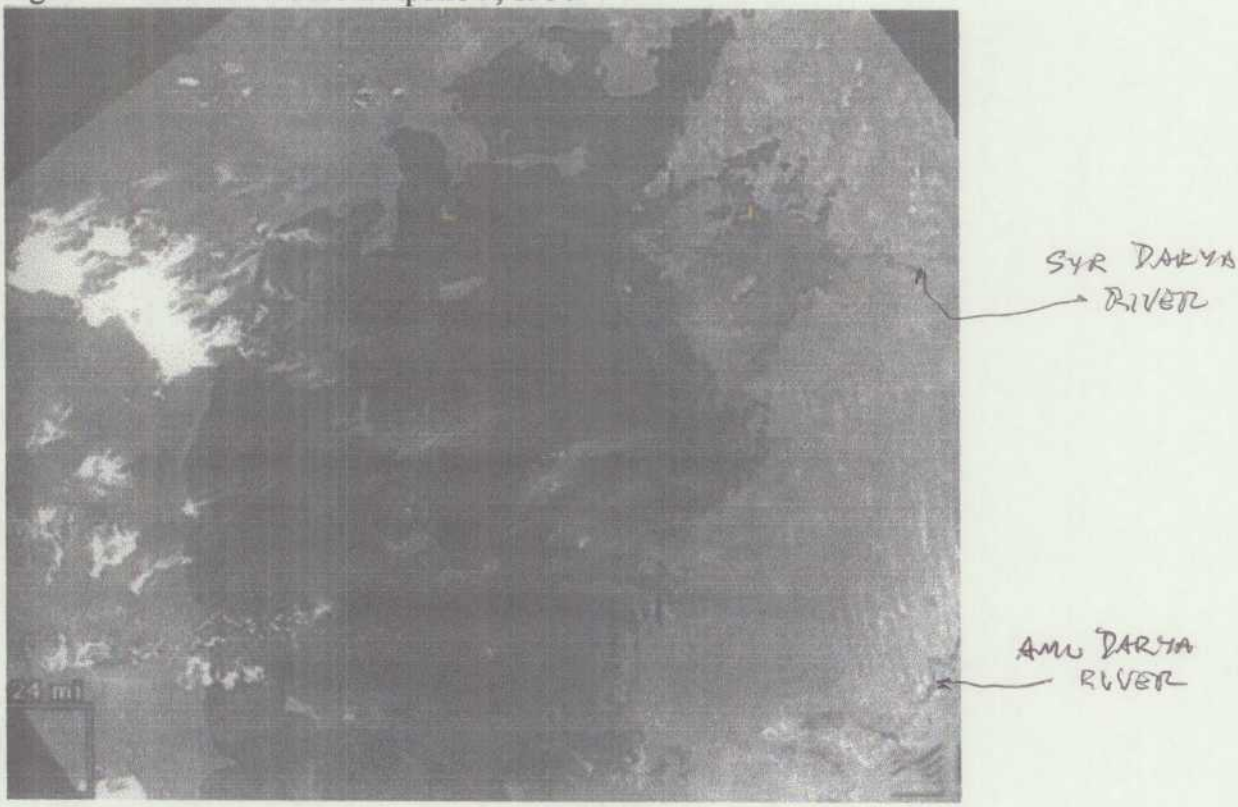
Lake Victoria has suffered a massive increase in nutrients. The population of the three countries is about 88,800,000, and the major source of nutrients is the absence of sewage treatment. (One data point found: "Residences with effective latrines or sewage treatment systems = 0.5%"). This has led to eutrophication of the lake. The lower levels of the lake have become anoxic, and of course, any deep water species are now extinct. The water hyacinth thrives on the high nutrient level and is beginning to clog large sections of the lake. First, local fishermen physically pulled the plants, and farmers chopped them up for use on their fields as mulch. After a dozen or more of these men were killed by the Hippos and Crocodiles that live in the hyacinth masses, that removal method lost popularity. Several other methods are now being used to reduce the water hyacinth infestation, with little discussion or experiment. A beetle that helps to control water hyacinth in Louisiana has been imported and put in place, as well as a South American grasshopper, and two Australian moths. It is too soon to see any change in hyacinth population, and fortunately so far the aliens have shown no undesired impact on native plant species. Uganda is impatient for improvement, and now is proposing extensive use of Roundup and 2-4-D. This would be a desperate measure, as these herbicides are poisons to people and animals that use the water, including the fish.

The "Tragedy of the Commons" is charging ahead at full speed in Africa. Instead of using "all knowledge" in planning their progress into the future, the people and the governments appear to be blinded to reality by contention between tribal groups, political and religious factions, and the struggle to survive in poverty, so that no real effort is made to address the environmental imperatives which will in the long run determine the life or death of the people and their countries. It is sad that the hatreds, disputes and struggles overpower the intellect, so that no resolution seems possible.

## The Aral Sea

The Aral Sea is a case in which the Tragedy of the Commons is caused by government action, but again, action without all knowledge. The Aral Sea was a large fresh water lake fed by two rivers that carry the melt waters from the western face of the Himalayan Mountains. It has no effluent stream, so is a fragile equilibrium ecosystem with the influent from the two rivers that feed it balanced against the evaporation from the system, and the water use by the people surrounding the lake. Figure 5 is a photo from Apollo 9, in 1964.

Figure 5: The Aral Sea from Apollo 9, 1964




With no outflow, all chemicals entering the Aral remain there, so the salt content of the water was slowly increasing. The lake was an extremely fragile and valuable resource for the entire area, worthy of careful protection. But the leadership of the USSR felt the need to improve their showing in the competition against capitalism, and so decreed that they would become a world leader in cotton production, using the two rivers that feed the Aral to irrigate the crop. It is obvious that spreading of the river waters over the hot desert soil would increase evaporation very significantly, so the Aral's fragile equilibrium would be upset. Also, cotton plants aren't very tolerant of salt, so to grow cotton in a saline soil required an excess of water to flush out the salt. Adding this salt to the Aral would have a great social and economic cost, which needed to be balanced against any possible profit, but nobody asked the question: "Should we really be doing this?" The USSR had some short term economic success as a producer of cotton, but at the same time, the Aral Sea became saline, causing a long term and probably irreparable economic loss. The continued loss of water due to increased evaporation caused a decrease in the volume of the sea as shown in Figure 6. They did attempt to compensate the fishermen by digging ditches in the exposed lake bed, that can be seen in the picture, to allow the fishing boats to reach port. These ditches finally were 40 to 60 km. long. Salt became more of a problem and the cotton production declined, but still their "leaders" persisted in the bankrupt policies, talking of grandiose technological solutions: "We will pipe in water from the great Siberian Rivers, and refresh the Aral basin!" But with the dissolution of the Soviet Union in 1991, the fate of the Aral was sealed. The old policies continued, with or without leadership. By 1996, the Aral Sea had lost 80% of its volume (figure 7) and had become so saline that nothing could live there. The dry seabed containing

Figure 6: The Aral Sea from Space in 1986

Figure 7: The Aral Sea from Space, 1997

herbicide and pesticide residues from the farm run-off is exposed. Current projections show the Aral will decrease further to less than half its present volume (less than 10% of its original volume) by as soon as 2010, with continuing decrease in land fertility due to salt poisoning, and continuing increase in illness from the worsening saltstorms and blowing environmental poisons (including selenium.) The United Nations and the World Bank are finally beginning to throw money at the situation, with slim chance for a cure.

This is a another example of the "Tragedy of the Commons" at work. Again, it is caused by the failure of the people involved to incorporate all knowledge into their planning.

The Salton Sea.

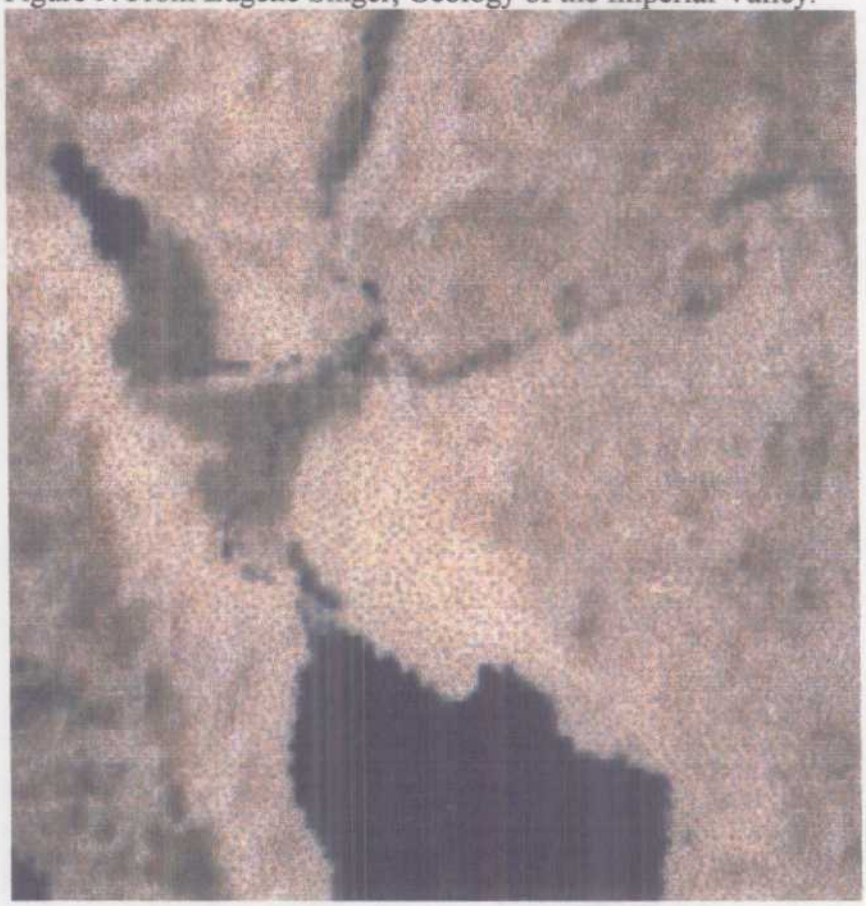
The San Andreas fault stretches through southern California, from Point Reyes north of San Francisco down the center of the Sea of Cortez. Its tendency is to split this large island away from the continent. It started this process by splitting Baja California from Mexico, forming a deep rift about as far north as Palm Springs, CA. allowing the ocean to flow north into the gully.

Figure 8: Estimate of California Prehistory

Figure 8 is my approximation of the prehistoric southern California area. Westerly winds built sand dunes that can still be seen along the eastern shore of this seabed. The Colorado River was gathering sediment from the erosion of all the great western canyons, and carrying it down into the side of the Sea of Cortez south of the present US/Mexican border. The ocean tides spread this sediment north and south along the bottom of the sea, gradually building up a dome shaped delta until it formed a dam holding back the ocean. The basin north of the dam began to dry up, with occasional breakthroughs of spring

floods from the Colorado opening the plug so the ocean again could connect and refill the basin. The last connection of ocean to basin was probably about 1500 AD. The Colorado delta is now about 40 m. above sea level, and the land slopes northward down into Death Valley and the Salton Basin, about 90 m. below sea level. Figure 9 shows the present configuration.

Figure 9: From Eugene Singer, Geology of the Imperial Valley.



The Southern Pacific Railroad built tracks across the basin, and hardy souls began settling there, drawn by hot springs and mud pots, and oases in the desert. Miners came in, looking for Borax, and to dig the salt deposits left by the drying of the ocean. The Liverpool Salt Factory (figure 10) was built in the bottom of the Salton Basin, where by merely plowing up the land surface, crystals of rock salt could be collected.

After the occasional rains that fell in the area, the desert "rejoiced" with a great bursting out of flowers. (Figure 11) An entrepreneur, seeing this, came up with an idea. This display showed the great fertility of the land, so all that was needed was water. As with most entrepreneurs, he felt his one idea was enough: who needs all knowledge? It was government land, so he didn't need a lot of capital to buy and sell land. All he needed was to bring in water, and bring in farmers, and he could make a fortune. He formed the California Land Development Company, and coined the name "the Imperial Valley" to make the desert more appealing, and got to work. He hired an engineer, who constructed a "header" on the Colorado River near Yuma, AZ. to control the flow of the water to the canal. West from the header stood the sand dunes mentioned above. Farther south into Mexico, centuries of Colorado River floods had washed away the dunes, leaving a flat

Figure 10: Plowing Up Salt for the Liverpool Salt Company

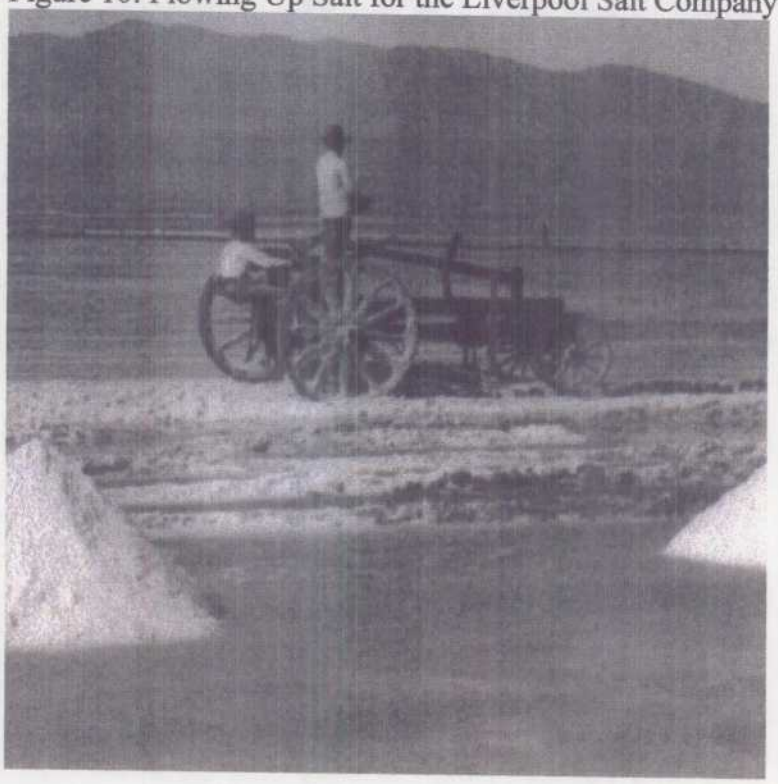
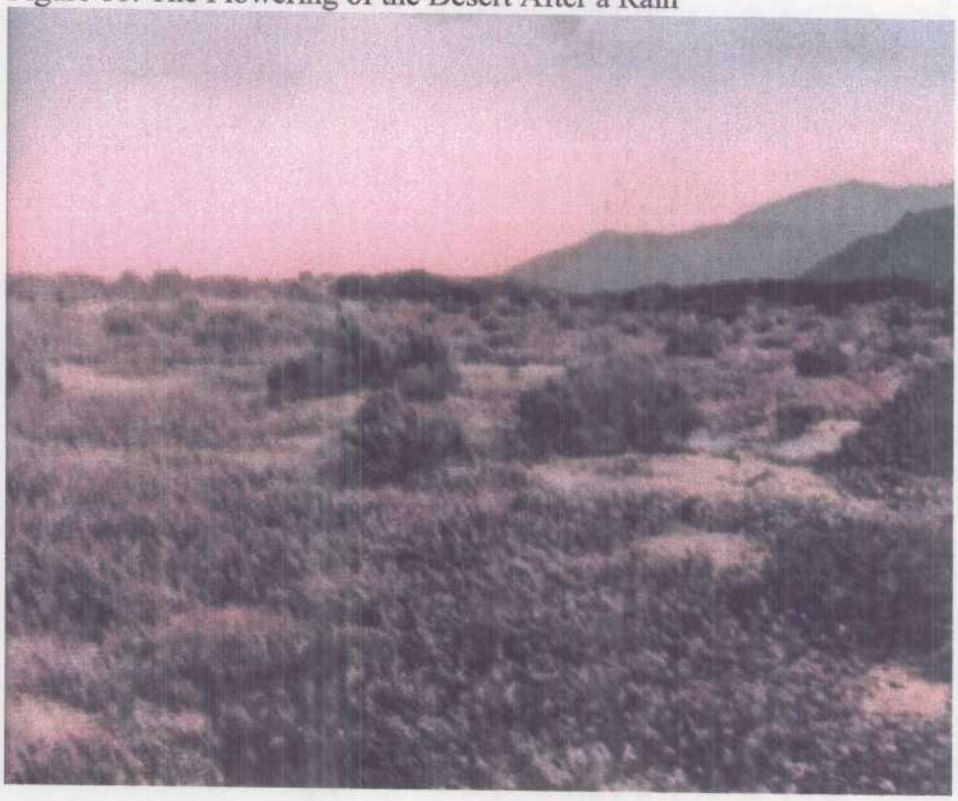


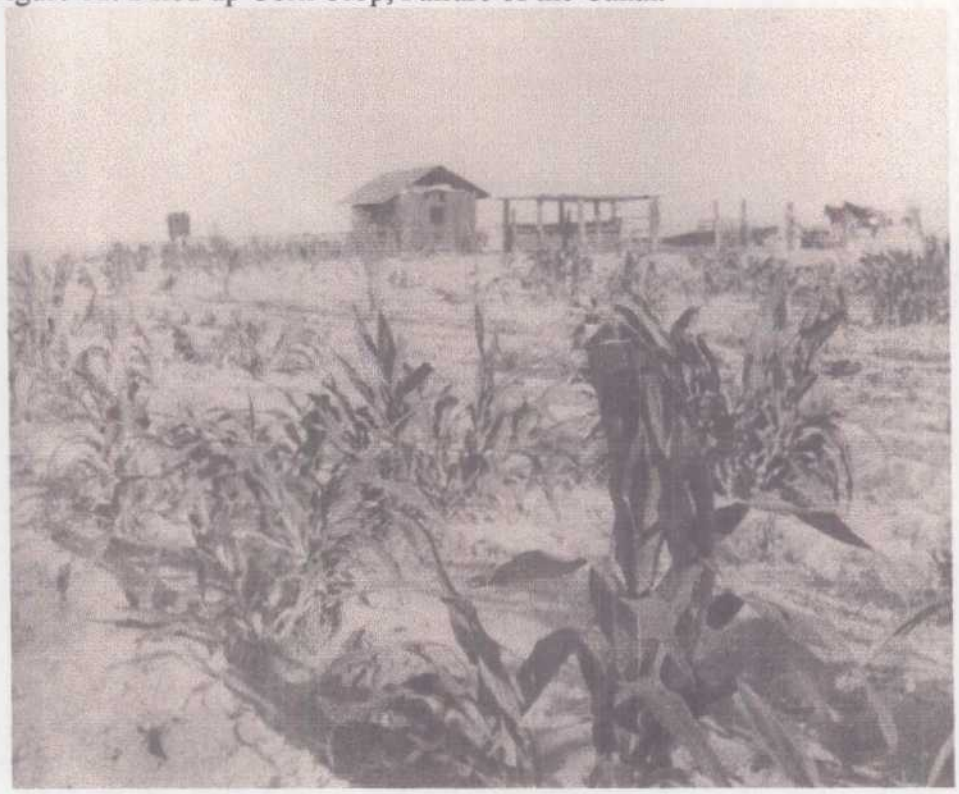
Figure 11: The Flowering of the Desert After a Rain



path across the delta, so he went south. He formed a shadow company in Mexico and with the promise of sharing water with Mexicali, got approval from the Mexican

Government. He bragged in his advertising that he used "mules and muscle" to dig his ditch. It went south, paralleling the Colorado, crossing the border into Mexico, then struck out straight west about 50 km. to Mexicali, then back north across the border into the Imperial Valley. He put ads in eastern newspapers, and the people flocked in. By 1902 there were about a thousand 100 acre land claims filed, and people were buying water. The land was as fertile as promised, and the climate allowed them to grow three crops a year. Money started flowing in, but the California Development Company didn't invest profits into equipment to allow maintenance of the canal. The chief engineer of the company made many demands for the equipment that would be needed to solve the problems developing in the system, so he was fired. . By 1904 the problems with the water supply could no longer be ignored. Sediment in the canal was reducing the flow to the farmers, causing crop failure.

Figure 12: Dried up Corn Crop, Failure of the Canal.



Looking at the ditch, he found that the first 8 km. south across the border were the part that was plugged the worst, so in December of 1904, he dug a new direct connection in Mexico from the Colorado to the ditch, and jerry-rigged a wooden gate to control the water flow. See? That was simple, and now we're back in business! In 1905 the winter storms in the Rockies were unusually heavy, and in the early spring melt, the high water destroyed the fragile control gate, and the river overflowed the surface of the valley. There was a steeper slope to the north than through the delta to the south, so about 85% of the total river volume flowed north. For 16 months a substantial part of the Colorado River flowed into the Salton basin. Since the main break was in Mexico, the US government couldn't do anything. Finally, there were telegrams between Pres.Teddy Roosevelt and the chief engineer of the Southern Pacific Railroad asking him to stop the flow.

Figure 13: The Start of the Flood into the Basin

Figure 14: Wreckage of the Southern Pacific Railroad Tracks

Figure 15: The Sinking of the Liverpool Salt Co.

Figure 16: Rooftop Rescue from the Flooding of the Salton Basin

The SPRR built new trestles to keep their tracks up out of the flood, and they lined up a continuous series of 100 car trains each made up of gondola cars filled with boulders and gravel. They were run across the trestle, dumping their loads into the torrent. Once stopped, the Colorado retuned to its previous channel.

Figure 17: Southern Pacific Railroad New Trestle Across the Flood

Thus was formed the Salton Sea, a moderate sized "Great Lake."

Look what we have here! The entrepreneurs just rushed in, to try to make a "killing" from the new environment (figure 18). The government stepped in and constructed the All American Canal (named to reassure the people that it was better than the previous one through Mexico.) In this case there was a settling basin to remove the sediment, and the canal was concrete lined and covered to decrease evaporation, so they were doing better planning than the original entrepreneur. Some of the Imperial Valley settlers gave up and left, but many toughed it out until the new canal was in operation. Still, not enough planning was undertaken. The amount of irrigated land increased rapidly. Because of the saline soil, excess water was used to wash out salt. This excess was run north through the Alamo River channel using the Salton Sea as a sump. There was little sewage control in the area, so raw sewage was included with the runoff from the fields, along with fertilizer, herbicides and pesticides washed from the farms, and naturally occurring poisons, such as selenium. The runoff was sufficient to keep the level of the Sea constant, so other entrepreneurs began to plan for the exploitation of this "great asset."

They stocked the lake with salt water fish, and began to organize "events" (boat races, etc.) to bring in the tourists. Almost before they got started, warnings had to be issued: don't eat the fish because of selenium poisoning and coliform bacteria. Soon the sport fish died leaving tilapia, put into the irrigation ditches to eat the algae. Later, even the hardy tilapia were poisoned, again piling dead fish along the shore. . A further series of upsets killed many of the birds that were attracted to the water

Figure 18: The New Entrepreneurs

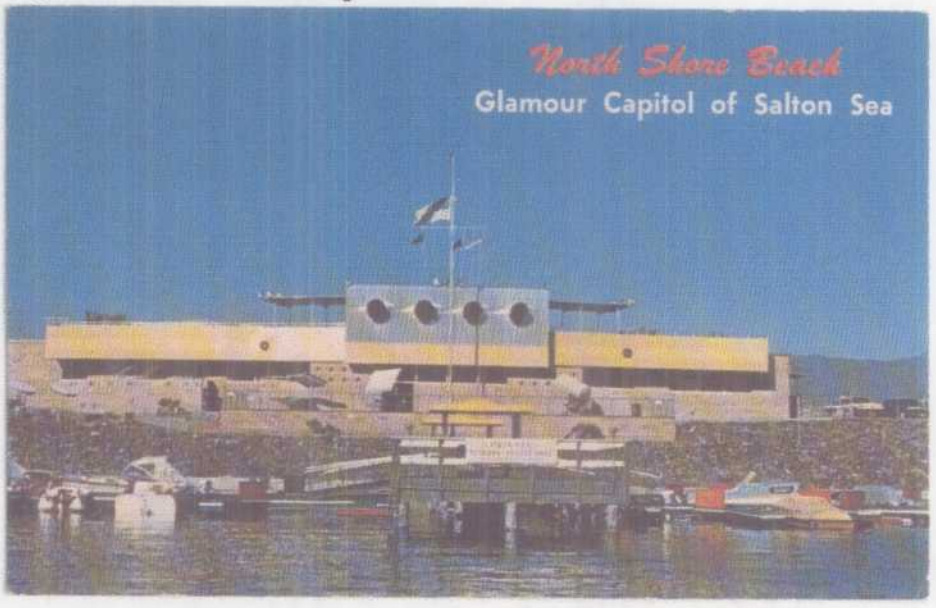



Figure 19: Fish Kill in the Salton Sea

. At each step along the way the entrepreneurial "leaders" involved tried to make a short-term profit, instead causing deterioration of the ecosystem, and in each case leading to long-term economic loss.

I wish to express my appreciation to the Coachella Valley Historical Society for the use of some of their pictures from the time under discussion, and to Dr Milt Friend, Chief Scientist of the Salton Sea Science Office for the pictures of the destruction of wildlife.

This is "The Tragedy of the Commons" in operation.
We need to find ways to ensure that all knowledge is used in any future planning.

This is a daunting task. In most of the operations of any system it seems that there are factors working against this ideal. Even in the best political systems, the desire to get reelected tends to put a 2 year limit on long term vision. In the corporate world, many of the leaders believe they must bow to stockholders short term economic interest, and limit their vision to the next year's (or even the next quarter's) bottom line. They try to avoid the realization that each corporation, like it or not, also has an environmental and a social (and dare I say it, an ethical) bottom line, which is poorly served by short term thought and action. And the entrepreneur is famous for his scrambling after the oxymoron, "Short term profit," to the detriment of himself and all around him.

The Salton Sea is a good example of this problem in the US, but many may think (or hope) that it doesn't represent the norm. On the contrary, I believe it is a rather benign case of the Tragedy of the Commons, because the entrepreneurs that caused it were very quickly made victims of their own foolishness. Unfortunately, more often the ones that cause the problems seem to be close to "getting away with it." An example of this was shown in the movie "Erin Brockovich", in which only by great effort and great good luck were the lawyers able to prove the corporate wrong-doing, and gain repayment of the losses that corporate foolishness had caused. Of course the older "Love Canal" case is another example. Smaller entrepreneurs are even more scornful of the environment in their search for the big buck. It may be necessary to put the environmental bottom line into the company thought process by putting punitive laws on the books that would make the rape of the environment prohibitively expensive, without requiring the victims of environmental crimes to file very difficult lawsuits to recoup the damages that they suffer.

There are many other cases of the Tragedy just coming to our attention. It seems that any commons available to us is at risk, and needs to be protected. For example, take a look at our aquifers. Everyone who draws his water from a well is dependent on such commons. How much do we know about how the aquifer we depend on is recharged, and what the rate of recharge is, and at what rate all the users of the aquifer are withdrawing water? Will our lack of knowledge soon face us with a big "Whoops!!?" It will if the rates don't match! That is the situation with the Ogallala aquifer in Nebraska, extending down into west Texas. Water is being withdrawn from this aquifer about 8 times as fast as the recharge rate. Still those using the water are showing no intent to change their water use, in spite of a 100 m. decline in the aquifer in west Texas. Instead, they are planning to use the deeper Dakota aquifer to supply their wants, without looking for information about its holding capacity and rate of recharge, and apparently unconcerned with the change to the Ogallala. Will we, like the residents around Lake Chad, keep going in our old ways until all water is gone? I have given some political and economic excuse for the people around Lake Chad. What's our excuse?

I am reminded of the earlier discussions of philosophy in my write-up of the failing Commons that was Lake Chad. Perhaps we can find the answer in the dominant philosophy that controls our actions. I'm afraid this philosophy is epitomized by the character of Alfred E. Neuman of Mad Magazine fame, and clearly expressed in his eloquent three words, as shown in figure 20.

Figure 20: The Philosophy of the Entrepreneur: What, Me Worry?