[5] Personal communication with Professor Henry P. Caulfield, Colorado State University

[6] Head, Dept. of Recreation and Parks, Texas A & M University. Personal communication.

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THE BALANCE OF NATURE MYTH

Jerry Caulder, Monsanto Company

On the morning of May 14, 1607, three ships, the Susan Thompson, Godspeed and Discovery, sailed up the James River from Cape Henry and put 100 men and four boys ashore at a point on a little peninsula.

This swampy, disease-ridden place was named Jamestown by the group of settlers who, by 1609, were on the verge of starvation and death from pneumonia, dysentery or malaria. This was the scene when man first set foot on the eastern coast of North America and began to upset "the balance of nature", which is often referred to in literature, but never precisely defined. No student of natural science, particularly of animal or plant ecology, could ever subscribe to a "balance of nature". The serious observer knows that animal and plant communities are in a dynamic state. While temporary equilibrium may occur and a given ecosystem may seem in balance, it is always progressing toward a climax condition. For example, if a "balance" ever existed, why do not animals and plants of the pleistocene or tertiary epochs inhabit the earth today? Why are not a few miserable men and women still huddled in caves cracking bones to obtain every morsel of nourishment from hard-gotten game? If nature were to ever strike its "balance", this was the time – man's influence on the environment was negligible.

The date when man first began to control or influence the environment is one of conjecture.

Early man and most plants and animals had to accept the environment as they found it and thus regularly became victims of "change".

The key word here is "change". We've all heard of the saber-toothed tiger, the dinosaur, the carboniferous forest? These organisms could not accept change. If nature were "in balance", could there be dramatic and long lasting changes? No, but we know that there is change – frequently abrupt, and sometimes catastrophic.

Plants and animals, if they are to survive, must either adapt to the environment or adapt the environment to their needs. Many plants and animals can adapt to the environment, but only man has successfully been able to alter the environment to fit his needs. Most plants and animals have developed habits and mechanisms to accommodate certain changes.

Many plants are able to survive cold weather because they produce seeds that remain dormant during the cold months. Some seeds, produced by desert plants, only germinate when they receive enough water to insure a complete life cycle.

With the animals, we look at the success of the crow. Its feeding habits are quite varied, so it adapts to many different diets depending on what food is available. On the other hand, the Everglade Kite, a bird that feeds exclusively on a giant fresh-water snail, will become extinct if anything happens to the snail. It cannot accept change.

Still other species have learned to avoid seasonal scarcity of food by migrating long distances. Water fowl, which nest in Canada, winter in the Gulf states and Mexico. Whales, seals and other aquatic animals have similar migration habits. Others choose to avoid adverse conditions by aestivating during high temperatures, like the bullfrog or box turtle, or hibernating during the winter like the bear or chipmunk.

Despite these many adaptations, most species of animals that have existed over the millions of years this earth has supported life have lost the battle to change and become extinct. Of all the animals that have existed on earth, it is estimated that 99% are now extinct. No, and I repeat, no 50 year period in recorded history is without numerous examples of animal species that passed from the scene – a balance of nature did not prevail. It is important to note that every niche capable of supporting life has been filled by a differing species. So the extinction of species is a naturally occurring phenomena. Nature is constantly changing. We should look at the modifications in plant cover or habitat that led to the extinction, and these changes should be judged on their merits – not what they caused – but what good can come from them. Who, among you, would be willing to live in the so called "natural" environment that existed at the time of Jamestown?

Nature is a difficult and unfeeling taskmaster if one is wholly dependent on her whims.

Primitive man existed, like any other animal, as a part of the environment, exerting very little influence on it. As time passed, man found that not only could he adapt to a hostile environment, but that he could change the environment to fit his needs.

Probably man's first significant step toward controlling his environment was the use of fire. This enabled him to move into the temperate regions that were formerly too cold. The temperate regions are our most productive ones, but man adapted to the cold winters that had prevented him from inhabiting these areas; man altered his environment with fire.

With the ability to think, man has, through the ages, been able to perfect means of improving his environment to contribute to his comfort and health.

Early man's thoughts centered around one simply thing – survival. And to survive, he needed two things, food and shelter. He needed shelter from both the elements and predators. He needed food for energy. This energy enabled him to gather more food – he had no time for other things in life.

Men, like other animals, began to establish "territories" or areas in which they felt safe from predators, but as wild game became scarce, they had to move and were once again exposed to predators.

This probably led to the first simple type of farming – man domesticated animals and planted a few grain crops. This way he had a supply of food with a minimum amount of exposure to his enemies.

This is essentially the way the Indians were living at the time of the Jamestown settlement. While the Indians in the early 1600's had carved small cultivated fields out of the land for corn, squash and tobacco, the men of Jamestown set into motion a pioneering, organized program of land use (not always the best, but man could learn from mistakes – nature in perfect balance would not allow a species to make mistakes.)

The history of agriculture can be divided into roughly three phases:
(1) man and animal tilling the soil; (2) man, animals and machines tilling the soil (1850); and, (3) man, machines and chemicals (1940).

In the first phase of farming, man and animal, there was little else in life. A man could barely produce enough food for his family and animals, so most people were farmers.

As man moved into the second phase of agriculture, man and machine, he could

produce enough food for himself and five or six other people. It's easy to grasp the significance of this: if some no longer had to work to produce food, they could produce other needed products, services. This eventually made possible industrialists, scientists, doctors, teachers, artists and the many professions that make life more enjoyable.

The scientists, freed from the labors of producing food, were now able to supply more and better equipment at a faster rate to the farmer than ever before. The results of these efforts are manifested in the fact that agriculture has advanced more in the last 50 years than it had in the first 50,000.

By the turn of the century, the average housewife was spending "only" forty per cent of the family income for food – notice I said only forty per cent – this was a relatively low amount by world standards. Compare with today's seventeen per cent. It is estimated that the United States is the only country that has significantly lowered the per cent of income used for food purchases.

The quantity of food being produced by the American farmer was unsurpassed by any in the world, yet his food quality was about the same. The quality of food suffered mainly because of three maladies: insects, disease, and weeds.

Farmers began to use substances to repel or destroy these pests: they were called pesticides.

Similar substances were used by doctors to protect humans: they were called medicines.

The use of pesticides quickly brought us into the third phase of agriculture – the chemical age. The chemical age has been by far the most successful: both food quality and quantity have improved beyond anyone's expectations. The farmer can now produce enough food not only for himself, but for 40 or 50 other people. This in turn frees even more people to engage in professions that were unheard of 30 years ago, such as nuclear physics, molecular biology, the space program, and many others. Recently, the Nobel Prize for Peace was awarded to an agronomist for his part in what is now called "The Green Revolution". If man had not significantly changed *his environment* to fit his needs, there would be no "green revolution" because there could be no hybrid crops, there could be no chemical fertilizers, there could be no pesticides to protect his crops.

Pesticides are the newest of the tools being used by farmers. Let us not forget that pesticides are tools, nothing more – nothing less. During the course of history most technological advances have been criticized because their uses have been misunderstood. When the metal moldboard plow was introduced to our prairie lands, many people feared that this metal would poison the earth; however, most of the people were farmers and they quickly learned that this was not the case. With pesticides we find these same fears being expressed; but as ninety-five per cent of the people are no longer farmers, the education of these people is not as easily accomplished. They are not directly involved in the primary uses or needs of these chemicals. These people, because of fear and lack of understanding, cry "pollution", a very popular word today. Unfortunately, a great deal of misinformation or partial information is being disseminated.

Let us face the fact that pollution is here and will remain for some period of time due to the nature of man, his society and technology. The problems can be minimized or overcome in time, but it will be impossible to cure all ills overnight. However, let us look at the role of pesticides as pollutants in the proper perspective. Industrial waste, automobiles, garbage, and sewage are the primary culprits. Do not misunderstand me – pesticides misused are pollutants, but when properly used, they are not a problem.

Pesticides are often linked with other pollution problems, when in fact no relationship exists. How many times have you heard of the DDT and mercury residues in fish caught in our Great Lakes, and then in the next breath they say the commercial fishing industry in Lake Erie is ruined because of pollution. This leads one to believe that pesticides have ruined commercial fishing in Lake Erie. In fact, it was ruined by waste and raw sewage being dumped there by Buffalo, New York; Detroit, Michigan; Cleveland and Toledo, Ohio. Such unrelated statements linked together lead the general public to wrong conclusions.

Agriculture is and will remain this country's basic industry, whether or not the general population wants to accept this fact. Everyone wants and needs to eat a balanced, nutritious meal at least twice, and preferably three times a day. This need and desire for food will continue and there is only one source – agriculture. Technology of production and marketing must be adopted at a faster rate if agriculture is to continue to supply the increased demand for food.

The use of pesticides is one of the technologies enabling agriculture to keep even or ahead of consumer demands. All indications are that the use of pesticides will accelerate within the foreseeable future or until such time that substitute control means and methods can be proven effective and yet economical for agricultural practicality.

The United States Food and Drug Administration (FDA) is committed to a safe, clean, and wholesome food supply. Regulation of pesticides in the United States has set a standard of excellence the world over. This is why the Ribicoff Committee wrote, "the food supply of the United States is the envy of the world, and the critical assurance that these abundant crops can be profitably grown, harvested, and stored is due to pest control, at present largely with chemical pesticides."

A pesticide cannot be used in the United States until it has received the approval of the FDA, which protects our food supply, the Department of Interior which concerns itself with our wildlife and environment, and the USDA which judges pesticide effectiveness and safety. Until 1970, these agencies operated separately. They have now been joined together into one department called the EPA (Environmental Protection Agency).

Chemical pesticides kill pests because they are toxic, and because they are toxic some are also capable, in excessive doses, of causing illness or death to people and wildlife.

Modern drugs save millions of lives, but some people have died because of them. It would not occur to anyone to ban penicillin because its annual death rate exceeds pesticides by several-fold. Penicillin can and will kill even when used according to prescribed methods. No death has ever resulted from a pesticide when directions were followed.

The automobile kills and maims, but it has changed our lives generally for the better.

Thus, society is continually faced with the task of balancing benefits against risks. The benefit:risk ratio is one that each of us face every day. We must constantly weigh the benefits of each action we take and determine if the benefit is worth the risks that we may incur. Most of us think nothing of getting in a car and driving for hours to reach a destination, but if an ice storm is eminent, we then see a change in the benefit:risk ratio, and may well decide to postpone the trip.

Scientists study pesticide safety by subjecting several species of laboratory animals to feeding tests and even feeding studies that cover three successive generations. The FDA then sets safe residue tolerances based upon available scientific evidence. These tolerances are set at 1/100th (or less) of the highest level causing no effect. For example, if it took over 100 ppm to cause some effect, the tolerance would be set at less than 1 ppm or well over a 100 x safety factor.

The same general approach of dosage versus toxicity should be followed in studies of carcinogenic and teratogenic characteristics of pesticidal chemicals. Apparently, they are not. Some of the more recent, highly publicized, laboratory investigations involving the food additives – cyclamates, the fungicide – captan, and the herbicides – 2,4-D and 2,4,5-T, have been performed with either large to massive, single, oral or injected dosages. The magnitude of these dosages greatly exceeded that of which our present knowledge would indicate could ever be ingested or accumulated by animals or man. This type of research is not a valid test of what a product will do or cause. To me, this parallels the type research that would result in this conclusion "rats force fed 20 gallons of distilled water per day developed bulging bladders."

Monsanto Company makes a herbicide called Ramrod. This product is available as a wettable powder and as a granule. When

we tried to get the granule cleared for use in corn, we were asked what effects these granules would have on pheasants if they ate them. Needless to say, of the animals we had run tests on, pheasants were not included. We, therefore, mixed granules with the pheasants' food – they would not eat the granules. We told the federal agency that they wouldn't eat Ramrod granules when given free choice. They replied that this was not good enough – food pressures may force them to eat the granules. We then put the birds on a diet of Ramrod granules and water: they still would not eat the granules. This still was not accepted, so we ended up stuffing granules down the pheasants' throats – needless to say, after a week on a diet of 80% clay, 20% ramrod, and water, the birds were not a picture of health, but the Ramrod had no effect, so we were given label approval.

Monsanto does not make DDT. In fact, all of our pesticides break down rapidly and harmlessly in the soil. As a result, they present no hazard to humans, wildlife or ecosystems. But DDT is the most popular scapegoat for the pesticide rap, so let me tell you about how some of the data on DDT were "derived".

The National Communicable Disease Center at Atlanta, Georgia, did a study of 35 men with 11 to 19 years of exposure in a plant that had produced DDT continuously and exclusively since 1947.

Medical examinations of these men revealed no ill effects attributed to a DDT exposure rate over 400 times that received by the general population. The overall range of storage of DDT in their fat was 38 to 647 ppm as compared to an average of 8 ppm for the average American.

So charges that the public is being poisoned by DDT in its food and drink seem without foundation.

The FDA monitors pesticide content of foods. These market basket surveys show that DDT and other pesticide levels are far below the permitted tolerances and they are going down, not up.

In 1966, 1967, and 1968, the total DDT and metabolites intake was 0.0010, 0.0008, and 0.0007 milligrams per kilo body weight, respectively.

Such small amounts of DDT intake by a 154 pound man would total 1.28 grams (0.148 ounce) of DDT during his lifetime if the DDT concentration in food did not continue to decrease. This is a minute amount when you consider that single doses of 5 grams or higher of DDT have been administered to humans for the successful treatment of barbiturate poisoning.

Pesticides have saved millions of human lives. The evidence is overwhelming: pesticides properly used are a benefit to mankind. Research must continue, however, so that this may continue to be true.

On the island of Ceylon, in the early 1950's, there were over 2 million cases of malaria. They began a DDT program to control mosquitoes and by 1963, they had so upset the "balance of nature" that there were only 17 cases of malaria. In 1964, they stopped spraying DDT, in 1968, they had over 1 million cases of malaria again. In 1969, they began to use DDT again.

Some of the more prominent national magazines do, on occasions, give the devil its due, however. Backhandedly, National Geographic, December, 1970, pays this compliment to pesticides. I quote:

"The World Health Organization went into Ceylon with pesticides to knock down the high mortality rate from malaria. It did a very good job of it. But its success – resulted in Ceylon's severe overpopulation problem and strained economy."

It is obvious what they are inferring – don't save lives with pesticides, you upset the "balance of nature".

When general statements and conclusions are drawn from highly specific bits of research, the general public is greatly misled. One of the most publicized stories about DDT is how it affects the metabolism of calcium in birds – thus causing a thinning of the egg shells. It is true that some species are affected. These are the ones we hear about.

Research at the University of Wisconsin found that DDT-fed pheasants exhibited no changes in reproduction rates. We would generalize this no-effect data just as well as some have the data on the bald eagle which did show a change in reproduction.

There are many studies where birds were fed diets containing 1,000 or more times the DDT present in the normal diet of the birds. DDT causes various effects on the physiology of the bird species at these high rates because it is a biologically active compound. But is it realistic to worry about such high consumption rates?

Concentration of DDT in the earthworm from spraying trees for Dutch Elm Disease has been shown to cause some deaths of robins in the sprayed area. However, repopulation soon takes place from population pressures in surrounding areas.

What is happening to our robin population can be shown by the Audubon Society bird counts made each year at Christmas time. Their reports for 1941 and 1960, before and after the widespread use of DDT, show the following increases for species all closely associated with man and his activities – grackles, 131 times; cowbirds, 21; and robins, 12 times.

By far the greatest effect of DDT on birds is to kill mosquitoes that carry serious diseases of wild birds, including malaria, newcastle disease, fowl pox and encephalitis.

One hears that since the chlorinated hydrocarbons are concentrated as they ascend the food chain, carnivorous birds at the top of this pyramid reach the highest concentration and face special problems. The decline of the osprey and bald eagle are often mentioned in this respect.

However, reports by ornithologists in the late 1800's indicated that the osprey was threatened even at that time. In 1962, ninety-one per cent of the eagles found dead were killed by violence, seventy-seven per cent by gunfire. Eagles and osprey move out when their habitats are destroyed by invasion of man.

A 1969 report in the pesticide Monitoring Journal indicated that pesticides were the possible – note, I said possible – cause of only one eagle death in 18 states and Canada.

Repeated reference is made to the food chain and how the loss through poisoning of even an obscure species that constitutes a link in this chain will have far-reaching and disastrous consequences.

But in the living world there are scores of food chains and many alternate routes for reaching a common goal. Food chains are not isolated sequences, but are interconnected with one another. This interlocking pattern is called a food web. Links in these webs and chains are repeatedly being broken within a single annual cycle. Nature is remarkable in the alternate routes she makes available to any one species.

The decline or disappearance of species is not unique to our times. It is estimated that 99% of the species that ever existed on earth are now extinct. The last example of a bird becoming extinct occurred when the final passenger pigeon died in 1914 in Cincinnati, Ohio.

A committee of the U. S. Fish and Wildlife Service published in July, 1966, a comprehensive study on 129 rare or endangered species of mammals, birds, reptiles and amphibians, and fish in the United States. Paramount cause mentioned was the loss of habitat and the disturbance resulting from man's activities.

Pesticides are often mentioned as a "possible" contributing factor to the decline of the osprey, bald eagle, peregrine falcon and California condor. However, these species were on the decline a long time before pesticides were introduced.

Recent stories have indicated that DDT will destroy our ocean food supply and oxygen because it alters the photosynthetic process in the algae, or phytoplankton. They painted a real doomsday picture and said that long before we would run out of food, we would die of asphyxiation because we depend upon photosynthesis for the oxygen we breathe.

Presumably these predictions are based on research performed by C. Wurster, and published in Science in March, 1968. Five species of marine algae were studied.

He induced the water in which each of these algae was grown to accept up to 500 parts per billion of DDT dissolved in alcohol. The natural solubility of DDT in water is only 1.2 parts per billion. This means that by means of alcohol the algae were exposed to concentrations of DDT that can never occur in nature.

At the 1 parts per billion level of DDT, photosynthesis in the algae was either not affected or showed possible stimulation. Photosynthesis in the algae was depressed as DDT concentrations were increased above 10 parts per billion – a concentration that DDT cannot reach in the ocean because any amount over 1.2 parts per billion would precipitate out.

Calculations show that if all DDT pro-

duced in the world each year were dumped in the oceans and there was no breakdown, it would take over 9,000 years to reach 1 part per billion of DDT in the oceans.

Do not misunderstand me. The extinction of any of our species is to be avoided if at all possible. However, the gradual extinctions of a species will hardly cause a ripple in the living world, so rapidly is the function it served taken over by others. I value, just as much as anyone, the California Condor, the whooping crane, the osprey, the grizzly bear and other endangered species, for these are cherished by me as a biologist. But I also recognize that the passing of the relatively few individuals, which make up these populations and have been declining for years, will have no significant impact on the environment.

In summary, man must manipulate the environment to survive. His survival will carry with it the survival of most plant and animal species. In fact, by his interest in wildlife, he will undoubtedly prolong the existence of species that nature would otherwise have eliminated. He will significantly enhance the population of species that are of economic value to him.

On the other hand, man must deliberately attempt to minimize the competition from pests that endanger his food supply or health.

The changes he institutes to survive will inadvertently affect some species. In this regard, man is no harsher an administrator of the environment than "nature", which is totally indifferent to the immediate present, or the welfare of any particular species. What is farming, but an attempt to shift nature in a direction that will help feed and clothe man. I cannot help but feel that there are more efficient ways of producing protein than buffalo grazing on prairie grass and carbohydrates from grains and berries growing wild.

Let me close by reading a short essay written by Dr. John Carew:

In Balance With Nature by Dr. John Carew **

In the beginning there was earth; beautiful and wild; and then man came to dwell.

At first, he lived like other animals feeding himself on creatures and plants around him. And this was called in balance with nature.

Soon man multiplied. He grew tired of ceaseless hunting for food; he built homes and villages. Wild plants and animals were domesticated.

Some men became farmers so that others might become industrialists, artists, or doctors. And this was called society.

Man and society progressed. With his God-given ingenuity, man learned to feed, clothe, protect, and transport himself more efficiently so he might enjoy life. He built cars, houses on top of each other, and nylon. And life was more enjoyable.

The men called farmers became efficient. A single farmer grew food for over 40 industrialists, artists, and doctors, and writers, engineers, and teachers as well.

To protect his crops and animals, the farmer used substances to repel or destroy insects, diseases, and weeds. These were called pesticides.

Similar substances were made by doctors to protect humans. These were called medicines.

The age of science had arrived and with it came better diet and longer, happier lives for more members of society. Soon it came to pass that certain well-fed members of society disapproved of the farmer using science.

They spoke harshly of his techniques for feeding, protecting, and preserving plants and animals. They deplored his upsetting the balance of nature; they longed for the good old days. And this had emotional appeal to the rest of society.

By this time farmers had become so efficient, society gave them a new title: unimportant minority.

Because society could not ever imagine a shortage of food, laws were passed abolishing pesticides, fertilizers, and food preservaties.

Insects, diseases, and weeds flourished. Crops and animals died. Food became scarce.

To survive, industrialists, artists and doctors were forced to grow their own food. They were not very efficient.

People and governments fought wars to gain more agricultural land. Millions of people were exterminated. The remaining few lived like animals, feeding themselves on creatures and plants around them, and this was called in balance with nature.

**In Balance With Nature is included as a part of this speech with permission from Dr. Carew. It first appeared in print in the American Vegetable Grower.

Population Supporting Potentials of Agricultural Systems

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Ecology includes a study of the interaction of populations. Food is the primary basic need of a population for survival and development. The ultimate size of a population depends primarily on its food supply. Agriculture is the primary basic producer of food for the highest kind of population, man.

Our objectives in agriculture must focus on production of an adequate supply of food, both in terms of quantity or total calorie intake and in quality which includes such factors as protein, vitamin and mineral contents of the food. The quantity of food per capita of population depends on the food producing area per capita and the yield of consumable calories per unit area. Of these the yield of calories per unit of land area is most important. To illustrate this, before 1700 the continental United States produced only enough consumable calories to supply an estimated one to two million Indians with levels of food which periodically left them in famine. Today this land produces enough food for 200 million people at a level never previously enjoyed by any people in addition to vast quantities for export and a surplus.

Total yield of calories per acre depends on two factors: (1) the yield of the crop per acre and (2) the inherent efficiency of the crop or crop-livestock system in converting energy to consumable calories. Many crops will convert sunlight, CO_2, H_2O, and minerals directly into products for human consumption. Examples of these include potatoes, rice, fruits, and vegetables. Other crop products can be used directly as food or converted to food products through animals such as cereal grains. A third group of plants, which must be processed into food by animals, include forage crops, and pasture. In general those crops which produce consumable food tend to yield more food calories per acre than those which must be converted to food by livestock. However, livestock provides the only means whereby we can obtain food from much of our land area which is best adapted to pasture or forage crops.

The consumable calorie production per acre varies among crops. An estimate of this for various crop and livestock systems is shown by the calculations in Table 1. These estimates are based on good production levels on highly productive land and livestock systems that are well managed. Maximum production levels however are well above these levels but average production levels are well below these levels. Of the systems shown, the calorie production per acre varies from 400,000 to 12 million calories per acre, a 30 fold difference.

The average consumption of calories per person in two areas of the world is shown in Table 2. As indicated the total calories consumed per person per day by the North Americans is about 50% greater than that consumed by the average Oriental. The quality of the diet differs even more as indicated by an eight-fold greater consumption of animal protein by the North American than by the Oriental.

Table 3 relates the calorie and diet quality difference between the Oriental and North American to the amount of land required to produce a yearly supply of calories per person. To simplify calculations the diet composition is only an estimate. Using these values, the basic production of 1.23 acres of highly productive land would provide the calories for consumption of one North American whereas the same production potential would provide the diet for nearly nine Orientals.

These calculations indicate the following conclusions:

1. The basic agricultural production of a country in terms of calories per person determines the calorie intake per capita in addition to the quantity and type of animal products that will be available per capita.
2. Gross inequalities exist in the basic productivity per capita in different areas of the world. The basic production has more influence on the