"We cannot impose our wills on nature unless we first ascertain what her will is. Working without regard to law brings nothing but failure; working with law enables us to do what seemed at first impossible."

—*Ralph Tyler Flewelling*

3 *Nature's Mysterious Rhythms*

One evening in 1940 I gave a talk, illustrated with slides, to the New York chapter of the American Statistical Association. After the meeting I happened to overhear one professor say to another, "I never saw so many coincidences in my life!"

What that scholarly gentleman meant, of course, was that the cycles I had illustrated and discussed were nothing but coincidences. I might have agreed with him about any one cycle, but I had faith that all of them could not possibly be coincidences. At that time, however, this was merely faith on my part, and I knew it. That faith has been strong enough to nourish me for more than three decades, and it has grown stronger with the years as I have watched "coincidence" piled on "coincidence," as the pieces began to fit together, and as the clues to the mystery were uncovered in mounting numbers. Faith is now being justified by indisputable fact.

I have never been one to go off the deep end by confusing *thinking* and *feeling* with *knowing*. "It looks as if there is something here," I would say to myself as I studied a series of figures, "but of course it may be nothing but chance, nothing but coincidence." (In the early days we did not know how to determine, mathematically, the number of times out of 100, or 1,000, or 10,000 that any particular cycle could come about by chance.)

How can one tell, in any given instance, whether or not a regular rhythm that one discovers is caused by a real underlying force or merely by chance? Let's begin with some common sense and simple logic. If a cycle has repeated *enough* times, with *enough* regularity and with *enough* strength, the chances are that it is significant. Such regularity cannot reasonably be mere accident.

Pick up a pack of playing cards and begin to deal, face up. The first card is red, the second black, the third red, and the fourth black. You now have two waves of a regular cycle—red, black, red, black. This could easily happen by chance.

You continue to deal. Red, black, red, black. Four times in a row now. This regular alternation could still be chance, but it couldn't be chance if it were to continue much longer.

Resume dealing. Red, black, red, black, red, black. Seven times now! It could still be chance but it is less and less likely. It begins to look as if somebody has stacked the cards. You go through the entire deck. Twenty-six times of alternating red and black cards! "Somebody certainly stacked this deck," you exclaim. "It couldn't happen this way by chance once in a million times."

You underestimate! The mathematical odds that black and red cards would alternate in twenty-six waves, accidentally, are *one in a quadrillion!* In this chapter you will be introduced to cycles that have repeated at least twenty-six times over a period of more than two hundred years. Later on you will meet cycles that have repeated more than one hundred times—*back to the year 600 B.C.!*

Will Nature's Clues Solve Our Mystery?

In the past thirty years a considerable amount of our research at the Foundation has involved cycles in the natural sciences, for three important reasons. First, rhythmic cycles are almost universal in nature. Second, natural-science cycles are usually much less complicated than human cycles and thus easier to study. Third, when the wavelengths of natural-science cycles are the same as wavelengths of cycles in the social sciences we have reason to believe that we are approaching the very heart of our mystery.

Unless you have studied the subject, you would be amazed at the universality of rhythmic cycles in nature. The abundance of birds, fish, insects, reptiles, microorganisms, and mammals fluctuates in rhythm. Tree rings, evidence of annual growth, are wide and narrow in rhythmic cycles. Water levels in our rivers and lakes go up and down in cycles. Earthquakes recur at rhythmic intervals. So do volcanic eruptions. Sedimentary rock deposits are first thick and then thin in layers that evidence rhythm. All aspects of weather show rhythmic cycles—although very complicated ones—and, of course, many stars pulsate rhythmically.

Thus we study rhythms wherever they can be found, not because we have any special interest in ornithology, herpetology, ichthyology, or geology, but because the cycles in these and other branches of natural science are often identical with the cycles of man. Because they are identical *they may have a common cause.*

For example, there is nothing very remarkable in the fact that there is a similar eight-year cycle in stock prices and in manufacturing production. You might expect that the one would go up and down with the other. However, if the weather *and* earthquakes *and* sunspot eruptions *also* have eight-year coincident cycles, you are confronted with a situation that makes you feel you are on to something big.

Studying nature's behavior, then, may teach us more about man's behavior. So, like Alice in *Through the Looking Glass,* we will momentarily turn our back on what we wish to know so that we will know it better. We will face in the other direction, away from the social sciences, and review a few mysterious cycles in wildlife, something that the United States Army Air Force, to their regret, once neglected to do in the early months of World War II.

The Battle of Ascension Island

Ascension Island is little more than a few square miles of volcanic matter situated in the Atlantic Ocean halfway between South America and Africa. It was selected in 1942 as an ideal spot for the Army Air Force to build a stopover landing field for their short-range medium bombers, which were unable to cross the ocean nonstop. Hurriedly they built their field, and the B-25's and the B-26's began their endless procession across the Atlantic. Ascension Island, however, is accustomed to another type of winged visitor, for it is the nesting ground of the sooty tern, a bird with a unique breeding cycle. It returns to its favorite breeding ground every 9.7 months to hatch its oversized eggs!

But the Air Force was not aware of this rhythm of nature, and soon after the landing strip was completed, thousands upon thousands of terns began swarming over the field, which, unfortunately, had been built in the middle of a nesting area.

The small web-footed creatures were more than a nuisance; they were a frightening hazard to the fliers. Whenever a plane took off or landed, the startled terns would leave the ground and fill the sky with tens of thousands of pounds of flying gull meat only slightly less dangerous than antiaircraft shells. Although the Air Force, in order to save lives and planes, might have been tempted to consider "genocide" on the sooty terns, they could not, for they had promised to respect the flora and fauna of the island.

To help resolve the dilemma Dr. James P. Chapin, an ornithologist with the American Museum of Natural History, was consulted. Eventually he collected sufficient data to compute that terns returned to nest every 9.7 months on the average. After discarding several ideas to force the birds to move away, he finally hit upon the simple process of breaking their eggs. He had learned that the parent bird rarely returned to the scene of a nesting that had ended in disaster. By forcing the adult birds to move elsewhere, he not only saved them as future breeding stock, but undoubtedly saved the lives of many young pilots.

What brings the sooty tern back in a 9.7-month cycle? In more temperate climates of the world, which have wide variations of climate, temperature, and weather conditions, birds have an annual breeding cycle. But Ascension Island is near the equator. There is no distinct change in the weather from season to season, nor is there any variation in the amount of daylight. Yet every 9.7 months a million or more terns arrive at Ascension to hatch their young.

The Odd-Year Bird

A small North American bird with the unlikely name of evening grosbeak is another winged creature with a baffling cycle. It migrates into New England in large numbers—but only in the odd-numbered years. Only three times since 1913 have the grosbeaks deviated from their strange timetable. They were due in 1915 but failed to show, coming instead a year later. In 1917 they returned to schedule, but came again in 1918 also. In 1937 they never bothered to show up at all. Except in these years they have made their appearance every odd-numbered year with dramatic regularity.

That the grosbeak's regularity was not perfect, over the years, demonstrates an important characteristic of many cycles: after an interruption they tend to return to their old rhythm. In 1937, when it was due, the grosbeak did not appear, but it did not come the next year either. It waited until its next "due" year, 1939, to return. The reason for this invasion of New England in an almost perfectly regular two-year cycle is not yet known.

The Stay-at-Home Bird

Nearly all bird populations fluctuate in cycles. Studies by J. Murray Speirs of the Research Council of Ontario concentrated on birds that frequent the Toronto region. He discovered that the northern shrike, the rough-legged hawk, and the snowy owl have populations that fluctuate in cycles of three to five years. The pine grosbeak has a five-to-six-year cycle, and the horned owl has a cycle of nine to eleven years.

Dr. Leonard W. Wing, through another study, concluded that the hairy woodpecker, the downy woodpecker, and the bobwhite have an abundance cycle of 50.7 months. Changes in bird abundance are usually associated with their migrations. Many experts feel that food scarcity, which seems to occur at cyclic intervals, forces birds to move toward strange but warmer country. Eventually, when their search is rewarded with a surplus of food, their fertility increases, they multiply, and they spread out over larger land areas.

But the bobwhite's activities almost destroy this explanation, for few of these small reddish-brown birds ever die *more than a mile* from the nest where they were hatched. Migration cannot possibly affect their population fluctuations, and yet they have a definite cycle of 50.7 months. Whatever force causes this cycle does so in their own neighborhood. And this force is not yet known.

The Rise and Fall of the Lynx

The Canadian lynx is another prime example of one of the most baffling aspects of animal life—its rise and fall in population . . . the cycle of abundance. Patrolling the northernmost regions of Canada in search of his favorite food, the snowshoe rabbit, the lynx moves with huge running strides on padded feet large enough to prevent him from sinking into the soft snow. But while he is a hunter, he is also the hunted, for his skin is instantly convertible to cash at the nearest trading post.

Unless we are trappers, hunters, or fishermen, we normally think of animal populations as relatively stable, a notion that is far from actuality. Animal populations vary tremendously from year to year, even from month to month. Since the lynx is a favorite of north-country trappers, year-by-year records of its population are available over a long period of time, and it thus makes excellent study material.

Of course, there are no actual lynx censuses, but there are records of the offerings of lynx skins by trappers, particularly to the Hudson's Bay Company. As the efforts of trappers to earn a livelihood are fairly constant, biologists feel that the records of skin offerings constitute a reasonably reliable index of the abundance of the animal in its wild state.

Now I ask you to look at an almost unbelievable "picture" of a cycle (see Figure 2). Note that this 9.6-year cycle in Canadian lynx abundance has been repeating itself in almost perfect rhythm since 1735.

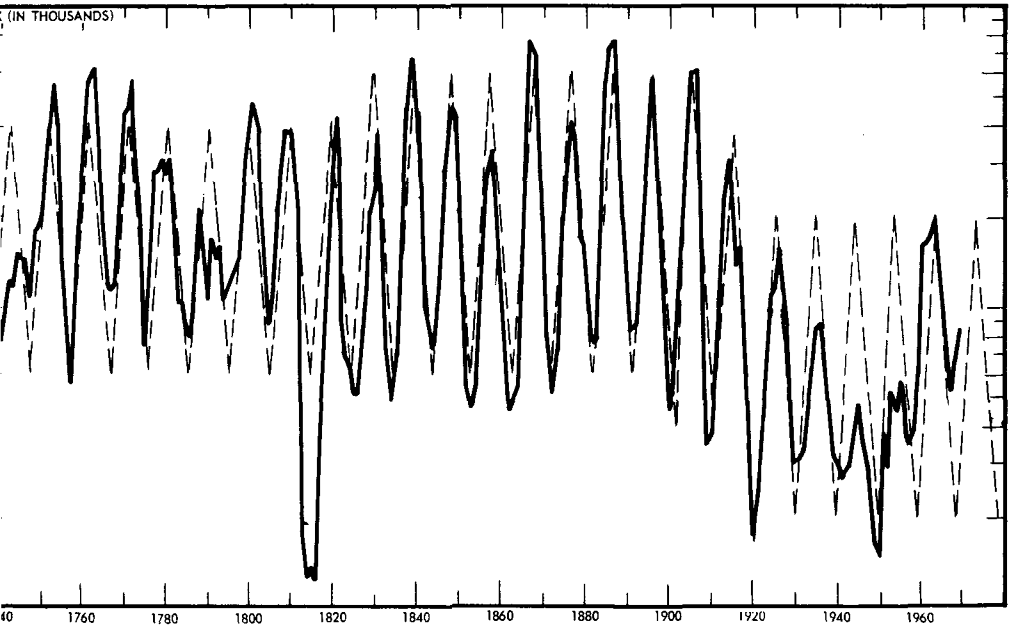

Fig. 2. The 9.6-Year Cycle in Lynx Abundance, 1735–1969

Note: To help you visualize the regularity of the cycle under discussion a broken zigzag line diagramming a perfectly regular cycle of the same length will be included in all cycle charts.

Except for the fact that during the last fifty to sixty years the catch has been considerably lower, the most notable features of this record are the tremendous fluctuations that characterize these figures and the amazing regularity of the fluctuations. The graph shows a range from under 2,000 skins in a poor year to over 70,000 in a good one. Intervals between one high and the next, or one low and the next, normally vary from eight to ten years. Over the span of the record they average precisely 9.6 years.

Because of the wide fluctuation in skins from a high year to a low, and because of its regularity, the Canadian lynx cycle has received wide attention. Although there is general agreement that it has not continued to fluctuate in such a regular rhythm for over two hundred years purely by chance, there is little agreement as to the cause.

One attempted explanation is based on a similar cycle in the rise and fall of abundance of snowshoe rabbits, the most important item of food in the lynx diet. But this raises an obvious and unanswered question. What causes the 9.6-year cycle in the snowshoe rabbit?

The 9.6-year cycle in population is characteristic of much wildlife. The coyote, red fox, fisher, marten, wolf, mink, and skunk have abundance cycles of the same period (average wavelength), all reaching their highs and lows in abundance at about the same time on the calendar.

In Illinois, and in much of the Midwest, a pesky white-winged insect called the chinch bug also has a 9.6-year cycle, at the peak of which up to 70 million have been known to cover one acre, wreaking havoc on cereal crops. Since it is rather difficult to imagine 70 million of anything, this reduces to 1,600 bugs per square foot!

Salmon, Lost and Found

Atlantic salmon fluctuate in abundance in a cycle whose period is identical with the lynx in Canada and the chinch bug in Illinois (see Figure 3).

The Restigouche Salmon Club is an ultraexclusive group of sportsmen who fish for salmon on the Restigouche, a river approximately 125 miles long flowing between the Gaspé Peninsula and New Brunswick and emptying into the Gulf of St. Lawrence. Careful records kept by its members of the catch of salmon per rod per day indicate that the abundance of salmon fluctuated in a 9.6-year cycle from 1880 to 1930. More recent figures supplied to me by the club's president pick up the identical rhythm, which is in step with the previous cycle. This is an important piece of evidence, indicating that here is a cycle that cannot possibly be ascribed to chance. I will elaborate on the significance of this in a later chapter.

In another 1960 study, traces of the same 9.6-year cycle in Atlantic salmon were discovered thousands of miles away in Wye, England.

The practical use to which cycle knowledge can be put is obvious in our brief look at salmon abundance, for the problem of

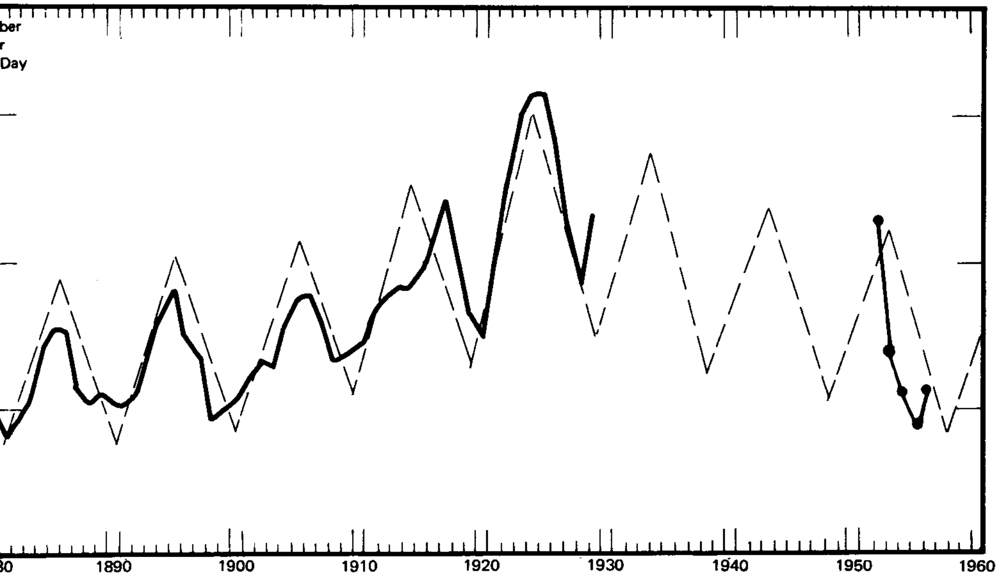

Fig. 3. The 9.6-Year Cycle in Atlantic Salmon Abundance, 1880–1956

Restigouche Salmon Club catch per rod per day, smoothed, 1880–1929; values 1952–1956 actual. No other values available.

occasional scarcity in this popular seafood is of vital importance to the European fishing industry. To be able to predict the good and bad years for salmon fishing can save thousands of man-hours and millions of dollars. We need not wait until we solve our mystery to take advantage of knowledge we already possess.

The Rodent Who Dies in a Cycle

The Norwegian word for "destroying" is *lemmus,* or lemming. On the average of every 3.86 years a six-inch rodent by the same name sweeps down from the hills of Norway in hordes, destroys everything in its path, and continues on until it reaches the sea. But it doesn't stop at the water's edge. It continues on, destroying itself by drowning. A few, who for some inexplicable reason remain behind, become the nucleus for the new horde that will migrate toward the sea, on the average, 3.86 years later. The cause of the lemming's rush to death on such a regular schedule is not known.

Norway also has a 3.86-year cycle in the abundance of foxes, and in the United States the growth of limber pine seems to have an identical cycle length. What obscure force could possibly affect the growth of certain trees in America and also influence the lemmings and foxes of Norway?

Trees, Prices, and Electricity

In the last paragraph I mentioned tree growth. Measuring this growth is accomplished simply by measuring the varying widths of tree rings. Trees grow by adding layers of wood. Winter growth is hard and compact. Summer growth is soft and porous. Cut down a tree and you can measure its rings for the growth of any particular year. When the tree has had a good year of growth, the layers for that year are thick; when growing conditions are poor, the layers are thin. There is a tendency for several pairs of thick layers to be followed by several pairs of thin layers. When this alternation is regular, we have rhythmic cycles in the tree-ring widths.

Arizona trees and their rings have been the subject of study for many years. One study, which traced the growth of trees back to the ninth century, indicates a fifty-four-year cycle. In England, coal, pig-iron, and lead production have the same cycle length. France has a fifty-four-year cycle in imports and exports and total foreign trade. In 1922 Lord Beveridge noted a fifty-four-year cycle in wheat prices, and the United States is now old enough to have experienced three such cycles in average wholesale prices. Coincidences?

Other cycles of a shorter length have also been discovered in tree rings, and one in Arizona of 16⅔ years has also been discovered in the trees on Java.

A third tree-ring cycle, forty-two years in length, is of interest because it has characteristics that we find in many of our cycle studies. Its forty-two-year cycle repeats for perhaps ten regular waves and then we will have only one high in the next eighty years or so. Then we might have two waves where there should be three.

Finally it resumes its old and regular forty-two-year rhythm as if the force that caused the forty-two-year cycle always existed but was diverted, for a time, either according to chance or to some law not yet understood.

Trees have another fascinating cycle. Their electric potential, or voltage, goes up and down in rhythm. If you drill two small holes vertically, a yard or so apart, in the trunk of a living tree and insert one end of a piece of wire into each hole, an electric current will flow along the wire, as if the tree were an electric battery. With a battery, however, the voltage is constant. In a tree the voltage varies. Also, the current from a battery always flows one way, but the current from a tree sometimes flows one way and sometimes the other.

Dr. H. S. Burr, of Yale University, has kept constant records of changes in voltage for a number of trees in the New Haven area, day and night, for many years. His records disclose two startling facts. First, the voltage in trees goes up and down in a cycle of approximately six months. Second, another tree of the same kind, even thirty miles away, behaves in the same manner. When the current flows up in one tree, it does the same in the other. When it flows down in one, it does likewise in the other. Dr. Burr attempted to link this change in voltage to possible similar changes in the barometric pressure, temperature, or humidity in the area, but eventually he abandoned all of these as the possible cause for the trees' strange behavior.

Let us examine this "clue" for a moment. What could possibly cause trees to act this way? Obviously the cause must be environmental. Something *unknown* in the air or in the earth must influence their behavior. But what? Since we see the effects we know there must be a cause. Something does exist to make trees act this way and this "something" has force, a force that repeats in a cycle. What is this force?

The Clearinghouse

In their search to understand nature several generations of scientists have noted the existence of rhythmic behavior. Working in their own field of interest, they often observed and commented on what seemed to be patterns and subpatterns in events. But prior to the creation of the Foundation for the Study of Cycles there was no clearinghouse that could gather information about cycles in meteorology, let us say, and pass this on to those doing research with cycles in economics, medicine, agriculture, or sociology. Some scientists, even today, are not aware of cycles in any field but their own.

Yet if cycles are truly characteristic of all living things, is it not logical that a knowledge of cycles, in animal abundance, for example, might provide the geologist or the meteorologist with information that could reinforce his own discoveries? Without this valuable interchange of cycle information between the various branches of science, will these dedicated people ever truly understand their own particular science?

Although your only interest in bugs may be to destroy those who feed on your rose bushes, let's assume for the moment that you are an entomologist and your life's work has been the study of the grasshopper. Because of your research you are aware that crop losses and pest-control expenses caused by these insects deprive farmers of millions of dollars each year.

However, your studies have been long and thorough and you are aware of the fact that the population of grasshoppers fluctuates in cycles and hence is partially predictable. You know that there are at least three cycles in the abundance of grasshoppers, one with a period of 9.2 years, one with a period of 15 years, and one with a period of 22.7 years. It is as if several forces were influencing their abundance simultaneously.

Now, of course, all three of these cycles are meaningful in your work but you are particularly interested in the 9.2-year cycle because it is the shortest one, and thus repeats most often. One day you happen upon some of the material published by the Foundation for the Study of Cycles, and what you read dumbfounds you, for you learn that the same 9.2-year cycle exists in many other phenomena. There are cycles of similar length in the water level of Lake Michigan, in the alternate thickness of tree rings, in business failures, and in prices. A 9.2-year cycle has been continuously present in pig-iron and copper prices since 1784; a 9.2-

year cycle has been evident in industrial-stock prices since their beginning in 1871, in railroad-stock prices since their beginning in 1831. Partridge abundance in Hertfordshire, England, shows a cycle of approximately 9.2 years, and tree rings at Santa Catalina, Arizona, tend to be thicker at 9.2-year intervals.

Later you discover other "coincidences." From an old issue of *Cycles,* the Foundation's monthly magazine, you learn that the Smithsonian Institution has published a paper by Dr. C. G. Abbot, based on forty years of observations, that states that radiation of heat from the sun varies in cycles of approximately 22.7 years, the same length as your longest grasshopper cycle. Also, in the same issue, you encounter your long cycle again at, of all places, an old Bohemian estate in Krumau, Czechoslovakia. Data on the annual bag of partridge from this estate covering a period from 1727 to 1909 show highs and lows at 22.7-year intervals.

The odds are great that your work in entomology will never be quite the same again. You will realize for the first time that the cycles you are dealing with in grasshoppers may be part of something much larger, and of fundamental importance to the world.

The Lowest Form of Life

No book that you can comfortably hold could catalogue all the known cycles in natural science. There are endless numbers of rhythms, some lesser known, such as the cyclic hatching of many insects, cyclic pigment changes, cyclic metabolic rates, cyclic chemical changes of the body—even cyclic variation of milk produced by cows. There is also the rhythm of feeding patterns of many animals, including bedbugs, chipmunks, rabbits, and lizards.

Even the amount of pollen gathered by bees fluctuates in a cycle.

Unlike Noah, I have made no attempt to include every species in my "ark," for it would sink from sheer weight and you would eventually cease reading from boredom. The purpose of this chapter has been accomplished if you are now aware that there is rhythm in nature. Later on you will meet many more cycles in nature as we compare them to cycles in other sciences.

But before we leave the birds and the bees and the lynx and the salmon there is one more cycle in nature that I cannot resist introducing to you. Drifting in the oceans and many freshwater lakes of the world are microscopic organisms called plankton. Although plankton is one of the lowest forms of life, it is, nevertheless, an important source of nourishment for most of the creatures that inhabit the underwater world.

Lowly though it may be, it has one thing in common with the grasshopper, the salmon, the partridge, the lynx, and even the tree. *It has a cycle of its own.* In 1926 a study of plankton in Lake Michigan was initiated by the Water Purification Division of Chicago and by 1942 more than 12,000 samples had been taken from the lake. The average annual total plankton yield suggested the occurrence of a periodic four-year cycle in which two rather high production years are followed by two rather low production years.

As with many of the tiny plankton's larger brothers and sisters in the world of nature there is no logical or accepted explanation for this cycle.