4. Weather Benefits and Other Environmental Amenities

The debate on climate change has usually focused on health, rising sea levels, increases in violent weather, or damage to agriculture. People's preferences for climate and for other amenity benefits, such as biodiversity, have received less attention. Rarely has research explored man's predilection for less chilly weather. Pleasant weather as well as a world populated with a diversity of living creatures are considered desirable and meaningful amenities. Men and women appear to prefer a world populated with living things, at least, at a distance. Although not all species are favored—reptiles, insects, and bacteria, to name a few, are not always welcome—most people want to maintain a globe inhabited by a large variety of animals, plants, and fish. Climate activists warn of a world with shrinking numbers of species as a warmer earth destroys their habitat. This chapter explores the public's taste for weather and for other intangible values that might be affected by climate change.

Given the circumstantial evidence that people favor warm climates over cold, it is somewhat surprising that the effects of warming on human well-being have been essentially ignored. We do know that, upon retiring, many people flee to southern and warmer locales. According to a 1966 survey of Americans turning 50 in 1996, almost 40 percent planned to move when they retired and the most important criterion in selecting their destination (40 percent) was a ''more favorable climate'' (*USA Today*, May 13, 1996, B1). People retire to Florida, not Minnesota. Presumably retirees, at least, find that higher temperatures improve their welfare. As air-conditioning has mitigated the rigors of hot summers, the population of the United States has been moving south and west, toward regions that suffer less extreme cold weather. Most Americans and Canadians taking vacations in the winter head to Florida, the Caribbean, Mexico, Hawaii, or southern California. Exceptions crowd the ski slopes, but they are a minority.

To my knowledge only one study—summarized in the U.S. Department of Transportation research described in the previous chapter—has examined human preferences for various climates, an important measure of how weather affects human welfare (Hoch and Drake 1974). Many studies examining the quality of life in various urban areas, however, have found that warmer climates are correlated with a willingness to accept lower wages (Hoch and Drake 1974; Hoch 1977; Cropper and Arriaga-Salinas 1980; Cropper 1981; Roback 1982, 1988; Gyourko and Tracy 1991). As a gauge of preferences, that research and this chapter both use workers' willingness to pay for a better climate as measured by the differential in wages among cities.

Human Well-Being

In *The Wealth of Nations*, Adam Smith pointed out that workers must be paid more to work in an unpleasant place or to do nasty jobs (Smith 1937, 100–18). A casual examination of the job market illustrates the truth of that proposition. Oil companies must pay their workers premiums to cope with the climate on the North Slope of Alaska. Even in central and southern Alaska, labor commands higher wages than it does in the lower 48 states. The differentials reflect the desirability of jobs in one area over another. Those who have the least distaste for cold and darkness, for example, can be lured for the smallest premium to Prudhoe Bay, Alaska, to work in the oil fields. The differential reflects the marginal valuation of the unpleasantness of work in that harsh environment for those with the least aversion to the conditions.

Theory of Amenity Values

There is a large and growing economic literature on such amenity values, that is, on characteristics that people value (Hoch 1977; Rosen 1979; Cropper and Arriaga-Salinas 1980; Graves 1980; Cropper 1981; Roback 1982, 1988; Blomquist et al. 1988; Graves and Waldman 1991; Gyourko and Tracy 1991). Locational advantage can be reflected in the willingness of workers to accept lower wages or in the bidding up by business and home buyers of land values (Roback 1982). If land values are raised enough, wages could even be forced higher to maintain real incomes. It is likely, however, that if workers willingly work for less in a region that they find attractive, the amount in wages that they are willing to forgo *understates* the benefits of the location. Some benefits have probably been capitalized into land values and are reflected in higher housing costs. Living costs are raised, thus reducing the amount of wages that workers will sacrifice to live where it is pleasant.

The relationship of wages to locational values becomes more complicated if the desirable qualities of the area affect the costs of the firm either positively or negatively. If businesses face higher costs because of the attractiveness of the area, wages must be lower for the firm to locate in a high-cost region. Companies planning to market nationwide that might prefer to build a plant in Hawaii, for example, would face much higher shipping costs both for supplies and to market their products in the continental United States. In effect, workers must accept a lower wage to induce employers to locate in a city or area that imposes higher costs on them.

Alternatively, if the amenity lowers the costs for the firm, more and more businesses will move to the area, boosting land costs. Eventually land costs will rise enough to discourage both employers and employees from locating in that favorable environment. The San Francisco area is a good example: its desirability for business and for many people has boosted land costs enough to force up wages. Generally we cannot predict whether good weather and other amenities that attract business and boost land costs will also raise or lower wages. Will the desirability of a location be so great that workers would be willing to accept lower pay even though they must pay more for housing?

Studies of the Effect on Land Values

A number of economists have examined the relationship of locational factors, such as the climate, to land values. Professor Jennifer Roback of George Mason University, for example, found that no climate factors had any significant relationship to land values (Roback 1982, 1272, table 3). Glenn Blomquist from the University of Kentucky and his economist colleagues from Kentucky and Michigan State University reported that precipitation, humidity, heating degree days, and cooling degree days were negatively related to housing expenditures—a proxy for land values—while wind speed, sunshine, and being close to the coast were positively related (Blomquist et al. 1988). Even though statistically significant, both cooling and heating degree days had very small effects on housing expenditures. Taking into account the effects of heating and cooling degree days on both wages and housing costs, the full implicit price of those variables was trivial. Two other economists, Joseph Gyourko of the Wharton School and Joseph Tracy of Yale University, reported that their measure of housing expenditures fell with greater precipitation, a greater number of cooling degree days, more heating degree days, and higher wind speed (Gyourko and Tracy 1991). On the other side, they also found that the higher the relative humidity and the closer to the coast, the higher the housing costs.

In sum, existing studies have reported mixed correlations between housing costs and weather-related values. Gyourko and Tracy (1991, 784) conclude their analysis of amenities by finding that ''for many city traits, the full price largely reflects capitalization in the labor rather than in the land market.'' The rest of this chapter, therefore, will assume that climate amenities have no effect on production costs; as a result, any measured wage reduction underestimates the benefits from warming.

Studies of the Effect on Wages

Economic studies have examined the relationship of amenities to wage rates. One of the first was the DOT's third conference on global climate change, referred to above, which used differences in occupational wages among urban areas to estimate the value of climate to workers. One of the tables, presented by Ralph D'Arge in his overview of the economic research, drew on the work of Irving Hoch, professor of economics at the University of Texas, to supply estimates of the costs and benefits of a 0.5°C warming (D'Arge 1974, 569). Hoch's research implies that a rise in temperature would bestow on workers an implicit gain of $1.6 billion in 1971 dollars (Hoch and Drake 1974). In other words, adjusting for 1995's level of wages and salaries and assuming that the temperature/wage relationship is linear, workers in 1995 would have been willing to accept about $47 billion less in wages for working in a 4.5°F warmer climate.

Although Professor Roback discovered no significant relationship between climate and land values, she did find that heating degree days, total snowfall, and the number of cloudy days were positively correlated with wages, all of which suggests that those are disamenities (Roback 1982, 1270). As expected, the number of clear days was negatively correlated with wages. She also found that the colder the winter (heating degree days), the higher the wages (Roback 1988). In summary, she was able to say that workers like warm weather without much snowfall in the winter and with few cloudy days. They must be paid more to put up with cold winters.

Economist M. L. Cropper of the World Bank reported an inverse correlation between July temperatures and wages for a variety of occupational groups (Cropper 1981). Not all the occupations exhibited statistically significant temperature relationships; but, with the exception of sales workers, all wages were inversely correlated with temperature, implying that workers preferred warm weather. An earlier paper, written with Professor A. S. Arriaga-Salinas, reported that the coefficient for July temperature was also negatively related to wages (Cropper and Arriaga-Salinas 1980). Their research supports the proposition that people like warm climates.

Expanding the scope of the research, Gyourko and Tracy reported that heating degree days were positively correlated with weekly wages (Gyourko and Tracy 1991, 782, table 1). In other words, the colder the weather, the higher the wages. Both precipitation and wind speed, however, were significantly negatively correlated with wages, a somewhat puzzling result. The results imply that people favor warm but windy, wet climates. Professor Glenn Blomquist and his colleagues, on the other hand, found that both heating degree days and cooling degree days were negatively correlated with their hourly wage variable, implying that workers like both cold and hot weather (Blomquist et al. 1988, 95, table 1).

All the studies show that hotter summers are related to lower wages. On the other hand, all the studies, except that of Blomquist et al., found that the lower the temperatures, the higher the wage. He reported that the warmer the January readings, the higher the wage, a peculiar finding. Except for the work by Blomquist and his colleagues, therefore, all these studies find that workers prefer hot summers and warm winters.

Empirical Results

This author, following Hoch's work, related wage figures to climate in various cities (Moore 1998). Data for 1987 from the Bureau of Labor Statistics on wage rates for secretaries, auto mechanics, and computer programmers (49 cities), word processors (43 cities), and tool and die makers (36 cities) were correlated with average annual temperatures and other climatic variables.

The relationship between hourly earnings and measures of annual temperature, the size of the population, and seasonal change produced the best results. Seasonal change was measured by the difference in the average high temperatures in July and the average low reading in January. A number of independent variables that might plausibly affect the desirability of various metropolitan regions were tried, including the crime rate, days that the city was in violation of the EPA's ozone standard, heating degree days, cooling degree days, the proportion of the population in the central city that was black, annual precipitation, plus a dummy variable for the South. None of these proved significant.

These statistical comparisons indicated that workers prefer warm climates to cool; they also like climates with substantial seasonal changes in temperature. This might explain the anomalous results of Blomquist and his colleagues mentioned above. The results suggested that the gains from a warmer world might range from as low as $30 billion to a high of $100 billion. Hoch's work, reported above, implies a gain of about $50 billion, a figure well within the predicted range.

Should warming lead to a bigger boost in winter temperatures and a smaller rise in summer, as suggested previously, the gain from higher temperatures would be offset in part by a decline in seasonal variation, leading to a smaller dollar benefit. If the entire rise in temperatures came in the nighttime (9°F), thus boosting winter lows with no rise in the day, seasonal variation would fall by 9°F and average temperatures would rise by 4.5°. In that case, since seasonal change would be reduced significantly without raising maximum temperatures, workers would be worse off by around $10 billion. On the other hand, if the rise in temperatures reflected the current relationship of average temperature to average winter temperature (increases of 1.5° for every degree the annual mean goes up) and to average summer temperature (rises only 0.5°), as mentioned in Chapter 3, the gain would be only $10 billion annually.

Analysis of Results

In all likelihood, these estimates of the value workers attribute to climate conditions underestimate substantially the tradeoff workers would make for warmer temperatures. If a warmer climate reduces costs to business by lowering transportation expenses, for example, land values will have to be bid up to achieve equilibrium. People attempting to locate in preferred areas will compete to find housing, making it more expensive for them as well as for companies. The higher rents mean that workers must be paid more to compensate. Thus the estimate of the value of a less frigid climate may be much too low. In addition, well-paid individuals prefer to live in pleasant climates, typically raising average incomes even of those who are less skilled.

Although it is impossible to measure the gains exactly, a moderately warmer climate would be likely to benefit Americans in many ways, especially in health and in satisfying people's preferences for more warm weather. Most people would enjoy higher temperatures, and the evidence supports the proposition that humans would live longer and avoid some sickness. Less cold weather would mean less snow shoveling, fewer days of driving on icy roads, lower heating bills, and reduced outlays for clothing. Technically, the beneficial results described apply strictly only to the United States, but it seems likely that advanced industrial countries in the middle or higher latitudes would benefit as well.

Valuations of Environmental Amenities

On the downside of climate change is the prospect of the loss of various species that are unable to adapt. Although paleontologists estimate that roughly 99 percent of all species that have ever existed have become extinct, most people feel it is a tragedy to lose additional unique animals and plants. The general public and scientists both value species for aesthetic, moral, and practical reasons; in medical research, for example, various animals and plants can provide valuable hormones, chemicals, or genes.

Some environmentalists have claimed that it is a tragedy to lose a single species. Edward O. Wilson, one of the world's most distinguished biologists, has contended that it is vital to protect all species (Wilson 1992). Although no one knows how many different species exist, many environmentalists claim that more species are going extinct than ever before. Given the evidence of mass extinctions in earlier epochs, that claim seems exaggerated.

Nevertheless, the issue has evoked concern. On May 21, 1997, 21 scientists sent a letter to President Clinton warning him that climate change would threaten biodiversity. They asserted that ''climate change, in combination with existing anthropogenic habitat disruption and loss, could lead to steep declines in worldwide biodiversity.'' According to the group, the speed of climate change would strongly affect the ability of species to adapt.

Current evidence suggests the opposite. Several scientists have recently reported an increase from 1981 to 1991 in plant growth in the northern high latitudes (Myneni et al. 1997). More vigorous plant development, while possibly choking out a few species, provides a more plentiful habitat for animals. Similar reports have originated in Australia where researchers have found that warmer weather, more rainfall, and perhaps greater CO_2 have led to bumper crops (Nicholls 1997). In this connection one should note that the IPCC has postponed and lowered its predicted warming of 4.5°F by 2040 to 3.6° by 2100 A.D., indicating that climate change will be considerably more gradual than believed previously. The evidence of greater growth in fauna, together with the lengthening of the period of any warming, suggests that fears of extinction of major species are overblown.

Moreover, biodiversity appears to be greatest in the tropics. Warm wet areas are more congenial toward species proliferation than are the temperate zones. Climate change is most likely to increase that portion of the globe that is moist and hot, thus increasing the potential habitat for many species. Plants and animals that have adapted to temperate or cold climates can move toward the poles. While cold climates are not devoid of animals and plants, the more frigid the climate, the more desert-like is the region, with only a small number of individual species. Antarctica is virtually free of plants and only a very few animals can withstand the rigors of that climate. A warmer, wetter world, therefore, is more likely to promote biodiversity than to destroy it.

African lakes, for example, teem with fish not found in other locales. Lake Malawi, a large lake (11,000 square miles) in East Central Africa, is home to more than 500 different species of fish, most of which are unique to that lake (Myers 1977). In comparison, the North American Great Lakes, an area nearly nine times the size of that African inland sea, contain only 173 different types of fish, with fewer than 10 endemic to those water bodies. Norman Myers (1977, 133), a Senior Fellow with the World Wildlife Fund, makes the point that "virtually every major group of vertebrates and many other large categories of animal have originated in spacious zones with warm, equable climates, notably the Old World tropics and especially their forests." He goes on to assert that "the rate of evolutionary diversification . . . has been greatest in the tropics." When he tries to assert the value to humans of this diversity, however, he falls back on the commercial value of plant-derived pharmaceuticals, a subject discussed below.

Climate change would, by definition, affect the pattern of temperature and rainfall to which animals and plants would be exposed. Although many species would adapt, especially as the change would take place over a considerable time period, not all would survive. In the pre-industrial world, animals and some plants adversely affected by a warmer world migrated northward to maintain a suitable environment. Environmentalists, however, now claim that humans have taken over so much of the globe that other animals might find it difficult to move northward. Moreover, those species that adjusted to a mountain ecology could move only a limited amount higher before reaching the summit. In both cases, a few species might not be able to survive.

In a higher CO_2 world, most plants would probably not be at risk. Although the temperature may well rise, an environment richer in carbon dioxide is likely to stimulate plant growth. Moreover, higher CO_2 levels induce a more efficient use of water in plants and make them more drought resistant. In addition, most models suggest that, worldwide, rainfall should increase. It would be perverse to assume that additional precipitation would fall only over the oceans. Nevertheless, there are some species of plants represented only by small numbers in very localized regions; some of these could become extinct.

If the earth warms slowly, as expected, almost all mammals could migrate to a climate that they found suitable. Ocean fish need not fear climate change; at worst they might have to swim farther north. Were local temperatures to rise to the point at which some species had difficulty reproducing and surviving, humans could and would transport and transplant many of them to more favorable climates. Certainly for cultivated plants and for domesticated animals, global warming should have little effect. It is true, nonetheless, that wild animals and many plants would have to adjust without human help and that unfortunately some of them might be threatened.

The Value of Biodiversity

Thomas E. Lovejoy, a noted environmentalist, asserts that (Reaka-Kudla et al., 1977, 8) ''biodiversity matters to human beings in a variety of ways.'' He goes on to stress that many items that humans consume stem originally from animal and plant life. A variety of plants and animals facilitate biotechnological advances that can provide better crops or other useful products. Lovejoy maintains that ''discoveries for the advancement of medicine and understanding of the life sciences constitute one of the most powerful ways in which biodiversity can contribute to human society'' (Reaka-Kudla et al. 1977, 9).

In the same volume, Ruth Patrick, who holds the Francis Boyer Chair of Limnology at the Academy of Natural Science of Philadelphia, makes the case that a large number of species help promote the well-being and existence of other animals, plants, and insects (Reake-Kudla et al. 1977, ch. 3). Patrick seems to be saying that biodiversity is important because it is necessary for biodiversity. Actually she is making a more subtle and important point: virtually all species rely on other species to maintain themselves and their habitat. This includes humans. For example, we depend on plants to convert carbon dioxide, which we breathe out, to oxygen, which we breathe in. Plants and animals provide us with food, clothing, shelter, and an abundant amount of goods. Those species in turn depend on others to flourish.

Nevertheless, the loss of a class of living beings does not typically threaten other species. Most animals and plants can derive their nutrients or receive the other benefits provided by a particular species from more than a single source. If it were true that the extinction of a single species would produce a cascade of losses, then the massive extinctions of the past should have wiped out all life. Evolution forces various life forms to adjust to change. A few may not make the adaptation but others will mutate to meet the new conditions. Although a particular chain of DNA may be eliminated through the loss of a species, other animals or plants adapting to the same environment often produce similar genetic solutions with like proteins. It is almost impossible to imagine a single species that, if eliminated, would threaten us humans. Perhaps if the *E. coli* that are necessary for digestion became extinct, we could no longer exist. But those bacteria live in a symbiotic relationship with man and, as long as humans survive, so will they. Thus any animal that hosts a symbiotic species need not fear the loss of its partner. As long as the host remains, so will parasites and symbiotic species.

Measuring the value of biodiversity objectively is probably impossible. Certainly people value plants and animals and would prefer that most, if not all, survive. Most men and women would be happy to see the cockroach, the mosquito, and the fly disappear. The extinction of poison ivy and poison oak would raise few regrets. Unfortunately, they are not the plants and animals that are the most vulnerable.

Economists have sometimes proposed surveying the public to estimate how much people would be willing to pay to preserve some amenity, such as a particular class of animals. Such ''contingency valuation'' surveys are unlikely to elicit correct estimates of the importance of the item being asked about, since those being asked do not actually have to pay anything. Moreover, when asked the value of an amenity, the respondent is unlikely to want to appear heartless and unfeeling and so will volunteer some amount. Typically the surveys focus on some attractive animal, rather than a rat, insect, or repellent species. The IPCC reports on one survey that inquired how much the public would pay to preserve a particular ''endangered species.'' The animals asked about included the bald eagle, the grizzly bear, the bighorn sheep, the whooping crane, the blue whale, the bottlenose dolphin, the California sea otter, the northern elephant seal, and the humpback whale (IPCC 1995c, 200). The values elicited ranged from $1.20 per year per person to $64 for those shown a video of threatened humpback whales. All the animals asked about have charm and sex appeal. Given the bias in this type of research, the figures have no validity. Even the IPCC authors say that one cannot simply sum the numbers to get an overall figure for the worth of biodiversity.

Some advocates of protecting species, such as the Union of Concerned Scientists, have argued that the animals' genetic pool could in the future prove of great benefit to humankind (UCS 1997). Within that huge pool of DNA may lie cures for cancer, heart disease, or more exotic ills. Genes code for—that is, provide the instructions for manufacturing—chemical compounds, which may provide the basis for pharmaceutical products. Pharmaceutical companies have already spent significant sums investigating naturally occurring chemicals and hormones that might provide real health benefits with the aim of finding compounds that can be modified to enlarge the pharmacopeia. Drug companies have recognized that evolution over hundreds of millions of years has developed many natural substances of benefit to human life. Preserving that diversity is important, therefore, to humankind. According to that view, the value of such diversity is immeasurable.

In keeping with this line of thinking, the United States has signed the Biodiversity Convention, prepared for the United Nations Rio meeting in 1992. That agreement commits the signatories to respect the sovereignty and property rights of local governments over any genetic resources or compounds discovered on their lands. Merck and Company has signed an agreement with Costa Rica to pay $1 million and substantial royalties for any product developed or discovered from indigenous plants or animals. Other companies and countries are negotiating similar agreements.

Being skeptical about the vital importance of maintaining every single species is tantamount to being against motherhood—at least before Paul Ehrlich convinced the world that babies were bad—so one is reluctant to question the importance of species diversity. Nevertheless, the usefulness of any one species, at least as a potential pharmaceutical, is probably low. Although the number of species on the globe is unknowable, it is certainly large: it has been estimated to be at least 10 million, of which scientists have identified about 1.4 million, about half of which are insects (Simpson et al. 1996, 176; UCS 1997). Among plants, there is considerable duplication in the production of chemical substances. Many creatures and plants have similar needs and consequently manufacture comparable compounds. As a result, identical drugs or comparable drugs can be produced from different species, either because evolution has led to the independent development of very similar chemicals in various species or because closely related plants or animals produce comparable compounds. The number of other plants or animals that produce like chemicals affects the worth of any one species. If many varieties of plants produce the same compound, the importance of any one kind is minimal. On the other hand, if very few code for therapeutic chemicals, the cost of discovery becomes excessive and the prediscovery desirability of any single species, negligible.

Moreover, if a species is found over a wide range, its value in any one area will be limited (Simpson et al. 1996). If all animals or plants in that species produce the chemical, additional individual members are redundant. Consequently, the worth of preserving any particular region that harbors the valued plant or creature may be very small.

A new substance's contribution toward more effective medical treatment determines its ultimate benefit, but it has to compete with existing drugs. Alternative drugs may be equally effective in dealing with medical problems. Even if a plant variety is unique, it may still provide no additional benefits over substances already known. Thus chemicals isolated from new species must compete with like substances found in other species and with existing known drugs. Finally, synthetic drugs based on inorganic chemicals often can be just as effective.

As economists David Simpson, Roger Sedjo, and John Reid of Resources for the Future point out, the value of a marginal species may be small. The worth of any species in the wild must take into account the cost of finding a representative by trained taxonomists who must carefully record its location and appearance. A sample must be dried, ground, and prepared for analysis, not a simple task. Extracts must be tested to measure the active compounds. All of this is expensive and takes time. According to Simpson and his associates, more than 10 years are required from the time of the discovery of a potentially valuable species until a new pharmaceutical substance is ready for sale (Simpson et al. 1996, 168). In part as a result, over recent decades drug companies have developed annually only a handful of new therapeutic drugs; the FDA approves only about 30 new substances a year, of which perhaps 10 are derived from plants. Those costs imply that the importance of unknown species may be quite low.

The Resources for the Future group has made an effort to value the marginal species under assumptions that maximize its worth. They take as their basis that of all the different types of plants, 250,000 plant species might each produce a useful drug. Making some reasonable assumptions, they calculate that the value of the marginal type of plant is less than $10,000. In their work, they assume a probability of a successful find that *maximizes* the value of the marginal variety. A higher or lower probability of making a hit would cut its value. This follows because the more species with an appropriate substance, the less valuable any single one will be; but the fewer there are, the more false alarms, and the more searching required.

These economists translate their findings into an estimate of the value of protecting a marginal piece of land. That estimate depends on the species diversity of the area. For the richest territory with the greatest diversity (western Ecuador), they estimate that the benefit of the marginal hectare is only $8.00 per acre. Other less species-intense areas are worth less, with California Floristic province* reckoned at 20 cents. The authors assert that these are upper estimates of the value.

Although people do like the concept of a globe inhabited by many different types of animals and plants, the value of any one or even many is not large in benefits provided to mankind. The Greek chorus of doomsayers grossly overstates the value of biodiversity. Their exaggerated veneration of each and every species leads to mistaken policy and needless expense.

*A region roughly bounded by Oregon in the north, the Pacific in the west, the Sierra Nevada in the east, and the Gulf of California in the south. This area is recognized by botanists as a separate evolutionary center, which contains one-fourth of all the plant species found in the United States and Canada combined. Half, or 2,140 species, are found nowhere else in the world.