Environmental rules occupy 42 volumes of the *Code of Federal Regulations*, more than any subject and its costs have been estimated as high as $220 billion a year.[71]

Uneven progress has been made in the attack on air, water, and land pollution. Protection has advanced, but there has been too little money, time, and political will to prevent widespread pollution-caused disease and damage to ecosystems.

In the next chapter we discuss methods for determining how regulatory programs can become more efficient and effective and also what voluntary actions corporations are taking to reduce their environmental footprints.

[71] Angela Logomasini, *The Green Regulatory State* (Washington, DC: Competitive Enterprise Institute, Issue Analysis No. 9, 2007), p. 9.

A World Melting Away

Between 200,000 and 400,000 years ago the polar bear (*Ursus maritimus*) evolved from the grizzly bear (*Urus arctos*), moving north from temperate forests into remote Arctic latitudes and all the while developing marvelous adaptations for survival, indeed domination, in a cold, forbidding world. It now seems the great bear's venture will fail as the habitat to which it so carefully adapted falls apart over the current century, a time so short as to be only three-hundredths of 1 percent of its evolutionary journey. *Homo sapiens*, a fellow traveler of the bear in time and space, is aware that fate is closing in and is trying, but not very hard, to prevent the bad ending. This is the story.

THE POLAR BEAR

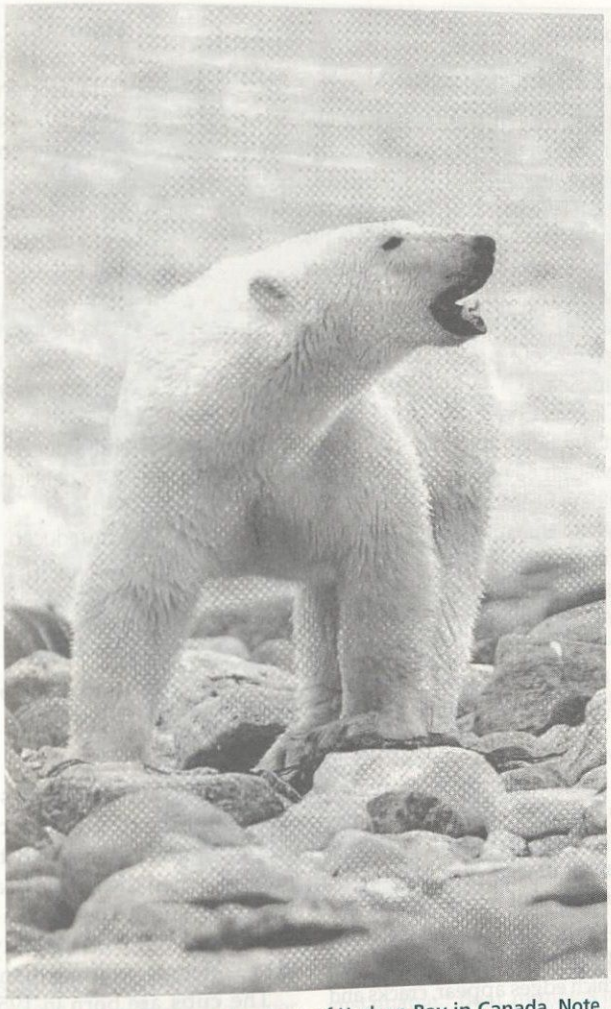
The polar bear is the largest species of bear. An adult male is two to three times the size of an adult female, weighing between 800 and 1,700 pounds and extending 8 to 10 feet in length. Females weigh only about 500 pounds, but can double their weight by gorging before they enter winter dens to give birth.

Polar bears are predators. Their main prey is the ringed seal (*Phoca hispida*), an elusive quarry because it is an excellent swimmer that can dive 300 feet and stay under water for as long as 45 minutes. Ringed seals venture farther offshore than other seals, living in areas of broken sea ice. They feed on shrimp and plankton in cold waters below the frozen surface, rising now and then to breathe through networks of holes in the ice they open with sharp claws.

Polar bears are adapted to hunt the seals. Big expanses of nasal mucus membranes in their noses endow them with an extraordinary sense of smell. They can scent a ringed seal from a mile away on land and through two feet of frozen surface ice. If a seal is resting on land, the bear will stalk it, creeping closer and closer, its white fur blending with the frozen landscape, finally charging at 25 miles per hour to disable its prey with the swat of a powerful foreleg. Polar bears are nimble on ice. Short curved claws and footpads that act like suction cups give them a foothold.

If a seal is on an ice flow, the bear may swim beneath, gliding under water for as long as two minutes, maneuvering its huge body with wide, paddle-like paws, then suddenly erupting from the water and grabbing the startled seal before it can plunge into the sea. Sometimes bears lie patiently at a breathing hole. When a seal rises there is an instant of violence when the bear smashes its paws through the ice, hooks the seal with short, sharp claws, and yanks it out of the water. The bear will rip the seal's body apart with sharp, curved teeth, gulping down chunks of blubber without chewing.

Bears also prey on other marine mammals including bearded seals, harp seals, and walrus pups. On land they will eat berries, bird eggs, grasses, and washed up whale carcasses. However, they cannot flourish without a diet rich in seal blubber. Polar bears store fat in their bodies. As mammals they need to maintain a constant body temperature and layers of fat up to five inches thick are excellent



A male polar bear on the shore of Hudson Bay in Canada. Note the slight ears, an evolutionary adaptation to avoid heat loss.
Source: AP Photo/The Canadian Press/Sean Kilpatrick.

insulation. Fat also adds buoyancy in water and can be metabolized to help the bear survive periods when food is unavailable. There are other protections from the intense cold as well. The bears have a wool-like undercoat and a dense outer layer of hairs up to six inches long. These hairs are impervious to moisture so the bear can shake off water before it freezes on the body. And their small ears and the small surface area to volume ratio of their bodies reduce heat loss.

Although there are stories of polar bears stalking humans, this is rare and commonly their actions are misinterpreted.[1] Having evolved as the top predator in Arctic regions the bears have no enemies in the animal kingdom. Therefore, they range freely without anxiety, approaching objects or movement with unalloyed curiosity. They wander up to campers, work sites, vehicles, villages, and roads. Ordinarily they do not see humans as food and will attack only if antagonized. However, oil companies hire bear monitors to watch for inquisitive ursine visitors at remote drilling pads.

[1] Richard Ellis, *On Thin Ice: The Changing World of the Polar Bear* (New York: Vintage Books, 2009), pp. 105–11.

EXHIBIT 1
The Arctic Polar Bear Population
These are estimates of polar bear numbers in the 19 populations studied by scientists. Many of the estimates go back to the 1990s. For some populations, as indicated, there are no reliable counts.

Population	Bears	Status	Current Trend
Arctic Basin	Unknown	Data deficient	Data deficient
Baffin Bay	2,074	Data deficient	Declining
Barents Sea	2,650	Data deficient	Data deficient
Chukchi Sea	Unknown	Data deficient	Data deficient
Davis Strait	2,142	Reduced	Declining
East Greenland	Unknown	Not reduced	Declining
Foxe Basin	2,197	Data deficient	Data deficient
Gulf of Boothia	1,592	Not reduced	Stable
Kane Basin	164	Reduced	Declining
Kara Sea	Unknown	Data deficient	Data deficient
Lancaster Sound	2,51	Data deficient	Declining
Laptev Sea	800–1,200	Data deficient	Data deficient
M'Clintock Channel	284	Reduced	Increasing
Northern Beaufort Sea	1,202	Not reduced	Stable
Norwegian Bay	190	Data deficient	Declining
Southern Beaufort Sea	1,526	Reduced	Declining
Southern Hudson Bay	900–1,000	Not reduced	Stable
Viscount Melville Sound	161	Data deficient	Data deficient
Western Hudson Bay	935	Reduced	Declining
Estimated global total	20,000–25,000		

Source: International Union for Conservation of Nature Polar Bear Specialist Group, "Summary of Polar Bear Population Status Per 2010," at http://pbsg.npolar.no/en/status/status-table.html, May 11, 2010.

The Northern Hemisphere circumpolar region where polar bears live is largely ocean. Frigid temperatures keep some surface waters frozen all year. This sea ice is the primary habitat of the polar bear. In the fall temperatures drop and areas of frozen ice enlarge. In the spring temperatures warm and the ice fields contract. This cycle of expansion and shrinkage creates dynamic conditions in which edges appear, cracks and spaces open and close, and sea currents shift ice floes around. All these movements create an arena where the bears can hunt seals.

Bears are powerful swimmers and travel easily in this environment. A mature bear may navigate a 600 to 1,000-mile journey over the winter as it hunts. As spring approaches the sea ice begins to break up and recede, and by summer polar bears move onto or close to land for four or five months, where they find less to eat and survive on their fat stores. When food is scarce, they conserve energy by sleeping and slowing their metabolism.

Polar bears have a low reproduction rate. Females have litters of one, two or, rarely, three cubs. The newborns are highly dependent on their mothers, staying with them for an average of 2.5 years before striking out on their own. So females breed at best only once every three years. Breeding occurs in spring or summer, but embryos suspend their development until autumn, when the female bear will excavate a den in new fallen snow. The den is a thermal refuge from the winter cold and with the body heat of the mother it is 18 to 37 degrees warmer than the air outside.

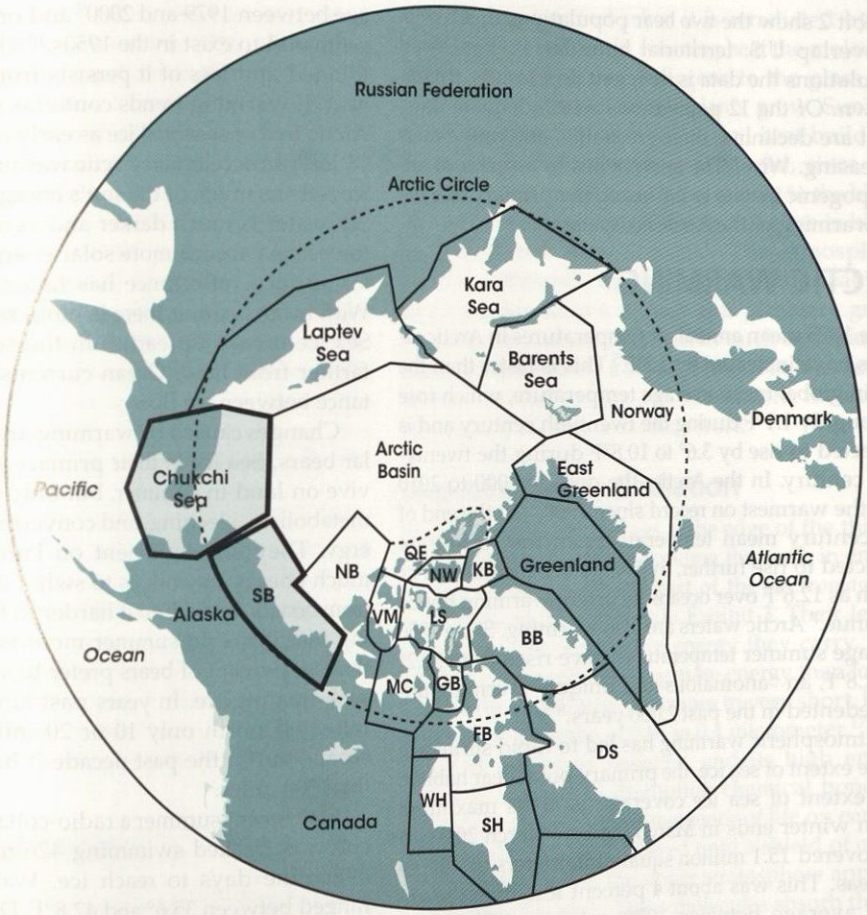
The cubs are born in 195 to 265 days weighing about 1.3 pounds. They grow rapidly as the mother creates milk from energy in her fat stores and nurses them. With the arrival of spring they emerge from the den. Mortality of young cubs is high, but falls each year. Adults between 5 and 20 years old have a 90 percent annual survival rate.[2]

Polar bears were once decimated by hunting. For centuries native hunters killed them for meat, hides, and status. In the twentieth century the natives were joined by rich trophy hunters from the south who tracked bears from airplanes and set automatic gun

[2] U.S. Fish and Wildlife Service, "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Polar Bear (Ursus maritimus) Throughout Its Range," 73 FR 28214, May 15, 2008.

EXHIBIT 2
Distribution of the Polar Bear Populations
The 19 population groups are designated here by name or initials. As indicated by the shaded areas, the Chukchi Sea and Southern Beaufort Sea populations lie within or overlap U.S. territory.

Source: U.S. Fish and Wildlife Service.



traps in remote locations. By the 1960s the bear population was only 5,000 to 10,000 individuals. However, in 1976 the five circumpolar nations—Canada, Russia, the United States, Denmark, and Norway—signed a conservation treaty limiting the harvest to subsistence hunting by natives and self-defense situations.

Russia and Norway now prohibit all hunting. Canada, the United States, and Greenland (a territory of Denmark) permit native hunting limited by strict annual quotas. Polar bears are still an important source of food, clothing, and income in native subsistence cultures, where polar bear hunts are an ageless source of prestige and cultural apprenticeship for young men.[3] The annual bear harvest is now between 500 and 700 bears, a number thought to be sustainable.[4] Bear numbers have rebounded and the world population today is estimated at 20,000 to 25,000, yet the number has little precision and the bear's world may be falling apart. Scientists divide polar bears into 19 populations that live in distinct habitats. Exhibit 1 shows estimates of the numbers for each of these populations.

Exhibit 2 shows the area that constitutes the Arctic, which includes the Arctic Ocean and the territories of five nations above the Arctic Circle, an imaginary line hemming the earth at latitude 66 degrees, 33 minutes North. The dark bordered areas in

[3] George W. Wenzel, "Polar Bear Management, Sport Hunting and Inuit Subsistence at Clyde River, Nanuvut," *Marine Policy*, October 2010.

[4] International Union for Conservation of Nature, Polar Bear Specialist Group, "Polar Bear Hunting, Harvesting and Over-Harvesting," March 15, 2009 at http://pbsg.npolar.no/en/issues/threats/over-harvest.html.

Exhibit 2 show the two bear populations that live in or overlap U.S. territorial boundaries. For seven populations the data is deficient and trends are unknown. Of the 12 populations with adequate data, eight are declining, three are stable, and only one is increasing. Why? The answer lies in a series of anthropogenic insults to the bears, the primary one being warming of the Arctic ecosystem.

ARCTIC WARMING

Since 1875 mean annual air temperatures in Arctic regions have increased by 2.2°F.[5] This is faster than the rise in global mean average temperature, which rose by roughly 1.1°F during the twentieth century and is projected to rise by 3.6° to 10.8°F during the twenty-first century. In the Arctic, the decade 2000 to 2010 was the warmest on record since 1900.[6] By the end of the century mean temperatures in the region are expected to rise further, by 5.4° to 9°F overall and as much as 12.6°F over oceans if current warming trends continue.[7] Arctic waters are also warming. Since 1850 average summer temperatures have risen from 38.2° to 42.8°F, an "anomalous and unique" warming unprecedented in the past 2,000 years.[8]

Atmospheric warming has led to rapid shrinkage in the extent of sea ice, the primary polar bear habitat. The extent of sea ice coverage is at its maximum when winter ends in March, and in March 2010 sea ice covered 15.1 million square kilometers of the polar seas. This was about 4 percent less than the annual average between 1979, when satellite measurements began, and 2000. Sea ice shrinks to its minimum extent at the end of summer in September. In September 2010 it covered only 4.6 million square kilometers, or 31 percent less than the annual average between 1979 and 2000[9] and only about half that estimated to exist in the 1950s.[10] The sea ice has also thinned and less of it persists from one year to the next. If warming trends continue, studies project an Arctic free of seasonal ice as early as 2040.[11]

Ice loss accelerates Arctic warming. Light-colored ice reflects much of the sun's energy back into space. Sea water is much darker and as areas of ice shrink the oceans absorb more solar energy. Since 1979 polar surface reflectance has fallen by 11 percent.[12] With more heating there is more rain and less snow. Sea ice breaks up earlier in the season and moves farther from land. Ocean currents increase the distance between ice floes.

Changes caused by warming are bad news for polar bears. Sea ice is their primary habitat. They survive on land in summer, but only by lowering their metabolism, sleeping, and converting fat stores to energy. They are inefficient on land, using twice as much energy to walk as to swim. As ice floes recede from coasts, bears find it harder to find suitable hunting platforms. In summer months of low ice fewer than 10 percent of bears prefer to stay on land. Most seek floating ice. In years past late summer sea ice retreated north only 10 or 20 miles from Alaskan coasts, but in the past decade it has retreated more than 300 miles.

One recent summer a radio-collared female with a cub was tracked swimming 426 miles without rest over nine days to reach ice. Water temperatures ranged between 35.6° and 42.8°F. During her journey she lost 22 percent of her body weight and her cub succumbed to exhaustion. It was an incredible feat, but researchers noted it had abnormally "high energetic and reproductive costs."[13]

[5] U.S. Fish and Wildlife Service, "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Polar Bear (Ursus maritimus) Throughout Its Range," 73 FR 28214.

[6] J. Overland, et al., "Atmosphere," October 14, 2010, in J. Richter-Menge and J. E. Overland, eds., *Arctic Report Card 2010*, at www.arctic.noaa.gov/report card, p. 8.

[7] Center for Biological Diversity, *Extinction, It's Not Just for Polar Bears* (San Francisco: CBD, September 2010), p. 4.

[8] Robert F. Spielhagen, "Enhanced Modern Heat Transfer to the Arctic by Warm Atlantic Water," *Science*, January 28, 2011, pp. 452–53. Ancient water temperatures are calculated based on types and counts of microfossils from sediment cores.

[9] D. Perovich, et al., "Sea Ice Cover," October 15, 2010, in J. Richter-Menge and J. E. Overland, eds., *Arctic Report Card 2010*, p. 17.

[10] Leonard Polyak, et al., "History of Sea Ice in the Arctic," *Quaternary Science Reviews*, February 2010, p. 1759.

[11] Ibid., p. 1757.

[12] M. G. Flanner, et al., "Radiative Forcing and Albedo Feedback from the Northern Hemisphere Cryosphere between 1979 and 2008," *Nature Geoscience*, January 2011. The decline is from 3.95 watts per square meter to 0.45 watts per square meter.

[13] George M. Durner, et al., "Consequences of Long-Distance Swimming and Travel Over Deep-Water Pack Ice for a Female Polar Bear During a Year of Extreme Sea Ice Retreat," *Polar Biology*, January 2010, p. 9.

In Hudson Bay sea ice now breaks up more than two weeks earlier than it did in the 1970s, shortening the polar bear's feeding season. Over this time the average weight of female bears has declined almost 150 pounds, lowering their reproductive rate.[14] If future ice breakup occurs one month earlier, it is estimated that 40 to 73 percent of females will fail to reproduce. And if breakup occurs two months earlier the failure rate will be between 55 and 100 percent.[15] Litter sizes will decline as breakup times advance.

Warming also hinders reproduction of the bear's prey. Female ringed seals build snow lairs on surface ice to hide their pups during six weeks of nursing. With increased rainfall, areas of abundant snow have diminished. In fact, warming has broadly disrupted a web of dependencies in the Arctic ecosystem.

With spring coming earlier some species have advanced the timing of life events. Plants unfold and flower, birds lay their eggs, and insects come forth as much as a month sooner than a few decades ago. This creates mismatching life cycles when other species do not shift their activities. In Greenland, for example, moss and lichen begin to grow earlier now, but the caribou have not moved up their annual migration to coincide with this dietary availability.[16]

GLOBAL WARMING

Recent warming in polar regions is well documented. So is global warming over the past century. Although cycles of climate warming and cooling have occurred over millennia, recent warming is singularly abrupt and is attributed to human activity, particularly the emission of global warming gases through industrial activity. These gases alter the *greenhouse effect*, an atmospheric mechanism that insulates the earth's surface from the cold of space.

The atmosphere acts to maintain a delicate balance between energy gained by absorption of sunlight and energy lost when it is reradiated by the earth back into space. In retaining heat the molecules of the atmosphere are analogous to the glass in a common greenhouse where plants grow. Sunlight comes through the clear panes, and heat builds up inside. Actually, the analogy is flawed, since heat buildup in the greenhouse is due mainly to the blocking out of wind currents; the action of glass in blocking reradiated heat is trivial. The atmosphere, however, efficiently traps 85 percent of the heat radiated from the earth's surface. This planetary greenhouse is not caused by a barrier such as a pane of glass; it is created by a set of predictable interactions between radiant energy and atmospheric molecules. Here is how those interactions work.

Incoming Solar Radiation

The sun's radiation arrives at the edge of the thin atmospheric envelope surrounding the earth in energy waves. These waves are part of the *electromagnetic spectrum*, which is shown in Exhibit 3. Their length determines the amount of energy they carry, with shorter wavelengths having more energy than longer ones. Some solar radiation comes in very short, high-energy wavelengths of 0.01 to 0.4 micrometer.[17] This is called *ultraviolet radiation*, and its high energy makes it capable of disrupting chemical bonds in plants and animals. The emergence of life on earth in prehistoric times was delayed until a shield of ozone molecules formed in the upper stratosphere approximately 30 miles high. These molecules absorb the energy in ultraviolet radiation so dangerous levels never reach the planet's surface.

The bulk of solar radiation, however, arrives in wavelengths between 0.4 and 1.0 micrometer, which overlap the spectrum of visible light. The characteristic blue of the sky results from the scattering of solar radiation in the 0.4 to 0.5-micrometer wavelengths when it hits small molecules in atmospheric gases. The eyes of humans and animals evolved to register solar radiation within the so-called visible-light range that is prevalent in the planetary environment. The eyes convert different wavelengths of solar radiation into specific colors.

Incoming solar radiation, called *insolation* from a combination of the words "*in*coming *so*lar radi*ation*," is absorbed when wave particles of light collide with

[14] U.S. Fish and Wildlife Service, "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Polar Bear (Ursus maritimus) Throughout Its Range," 73 FR 28254.

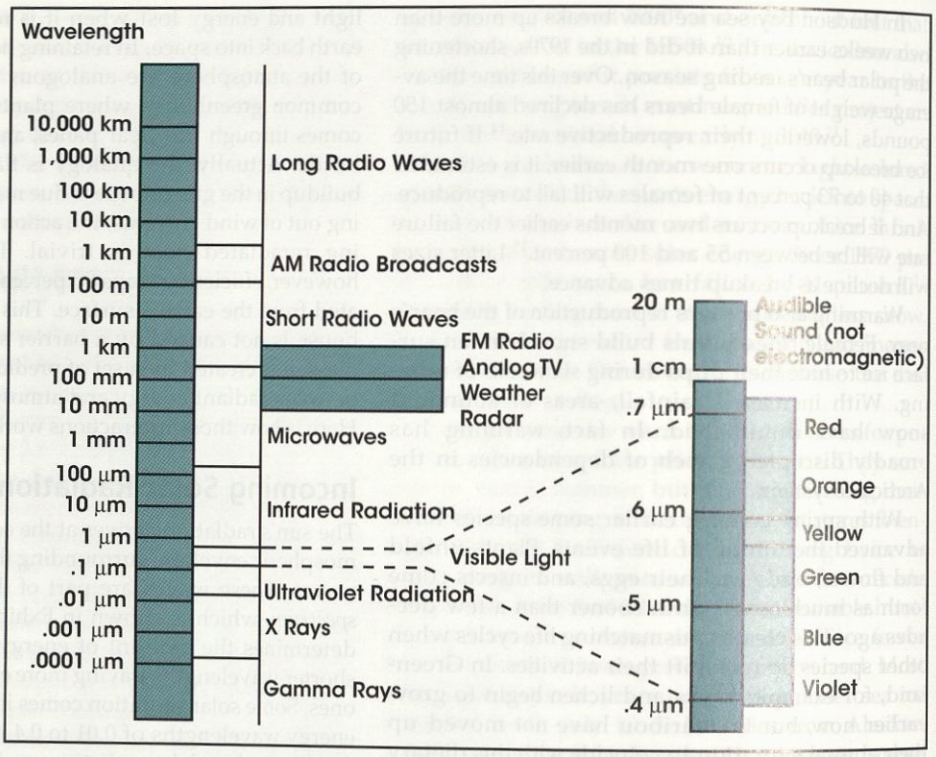
[15] Péter K. Molnár, et al., "Predicting Climate Change Impacts on Polar Bear Litter Size," *Nature Communications*, February 8, 2011, pp. 3–4.

[16] Center for Biological Diversity, *Extinction, It's Not Just for Polar Bears*, p. 30.

[17] One micrometer equals one-millionth of a meter.

EXHIBIT 3
The Electromagnetic Spectrum
Ultraviolet radiation from the sun, visible light, and the infrared radiation given off by planet earth are different wavelengths on the same spectrum.

Source: Joe R. Eagleman, *Meteorology: The Atmosphere in Action* (Princeton, NJ: D. Van Nostrand, 1990).



atmospheric molecules.[18] When collision occurs, energy in the light ruptures molecular bonds and moves electrons in the atoms into new orbitals; thus radiant energy in sunlight is converted to energy stored in these atoms. This conversion also causes a temperature rise in the upper atmosphere where it occurs. The process is analogous to making a space on a bus bench by shoving aside the person sitting where you want to sit. The bumped person is still there but in an angry, more energetic, agitated mood. The atom with an *excited electron* is more likely to combine with other atoms in the atmosphere to form a molecular compound. When, for example, ultraviolet radiation strikes ozone molecules in the stratosphere, they are broken down into excited oxygen atoms that tend to seek out other oxygen atoms and molecular oxygen to form ozone once again.

[18] A description of the precise nature of light is elusive. Light has some properties associated with waves, such as amplitude, wavelength, and velocity. It also has some properties associated with particles and has been described in terms of energy units called quanta.

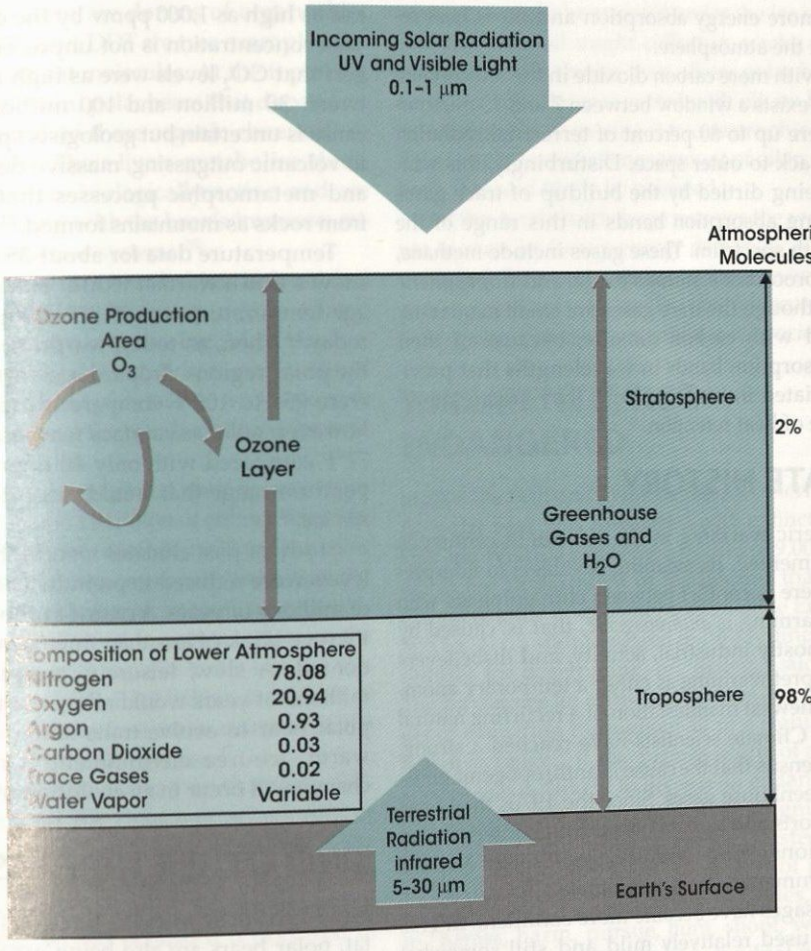
The wavelengths of solar radiation that a molecule will absorb constitute its *absorption band*. Simply put, atmospheric molecules absorb wavelengths that carry an amount of energy roughly equal to that needed to excite an electron to higher energy levels. Molecular nitrogen and ozone in the atmosphere have strong absorption bands in the short wavelengths and block out insolation at wavelengths up to 0.3 micrometer. Beyond that, in the range of 0.3 to 0.5 micrometer, insolation is not absorbed before reaching the surface. Between 0.4 and 1.0 micrometer, the remaining range of the strongest insolation, water vapor in the air is strongly absorbent.

All told, the atmosphere absorbs 25 percent of insolation and reflects 5 percent back into space. Another 22 percent is absorbed or reflected by clouds. The earth's surface reflects about 3 percent back into space. Thus, only the remaining 45 percent of the sun's energy is absorbed by the surface.

Terrestrial Radiation

Solar energy absorbed by the earth's surface is retained as heat that is radiated back into the

EXHIBIT 4
Structure of the Atmosphere



atmosphere. There is an important difference, however, between this outgoing *terrestrial radiation* and the incoming solar radiation. Radiation from the earth is given off in much longer wavelengths (see Exhibit 4). The reason is that the wavelength radiated by a body is inversely proportional to the temperature of that body.[19] The mean surface temperature of the sun is 5,800°F, so most of its energy is radiated in short wavelengths. The mean surface temperature of the earth, however, is a dramatically cooler 57.2°F, so radiation from its surface is in much longer wavelengths–from 5 micrometers to 30 micrometers, with peak radiation between 8 and 18 micrometers. This is *infrared radiation*.

[19] This is Wein's law.

Because their absorption bands are closely matched to infrared wavelengths, gases in the atmosphere absorb terrestrial radiation more efficiently than insolation; almost 85 percent of radiant energy from the surface is absorbed or reflected back to earth by the atmosphere. This absorption of radiated energy from the earth is the greenhouse effect. Infrared radiation is strongly absorbed between 0.5 and 7 micrometers and then upwards of 18 micrometers by water vapor. There is a "water window" between 7 and 18 micrometers through which outgoing radiation can escape. But it is partially closed in the wavelengths from 13 to 17 micrometers by atmospheric carbon dioxide. The growing concentrations of atmospheric carbon dioxide created by industrialization have increased the opacity of this window,

causing more energy absorption and more heat retention in the atmosphere.

Even with more carbon dioxide in the atmosphere there still exists a window between 7 and 13 micrometers where up to 80 percent of terrestrial radiation escapes back to outer space. Disturbingly, this window is being dirtied by the buildup of trace gases with strong absorption bands in this range of the wavelength spectrum. These gases include methane, chlorofluorocarbons, nitrous oxide, and tropospheric ozone. Although the trace gases are small in quantity compared with carbon dioxide, because of their strong absorption bands in wavelengths that previously radiated into space freely, they are an important cause of heat retention.

CLIMATE HISTORY

Atmospheric warming in the twentieth century is well documented. Its meaning is subject to interpretation. There is conflict between climatologists who believe warming is *anthropogenic*, that is, caused by human, mostly industrial, activity, and disbelievers who interpret warming as either a temporary anomaly or the newest manifestation of a recurring natural variation. Climate scientists have reached a strong, wide consensus that the cause is anthropogenic emission of greenhouse gases. Since the 1970s they have issued reports and assessments through international organizations, most recently the United Nations Intergovernmental Panel on Climate Change (IPCC). Their messages have become more confident. In 1995 the IPCC used relatively mild and still somewhat tentative language when it said "the balance of evidence suggests a discernable human influence on climate."[20] In 2007 the IPCC issued a new report asserting that "warming of the climate system is now unequivocal" and "very likely due to anthropogenic [greenhouse gas] increases."[21]

Climate history is instructive. Atmospheric CO_2 has risen from about 270 parts per million by volume (ppmv) before the Industrial Revolution to 390 ppmv today. Absent actions to mitigate emissions it could rise as high as 1,000 ppmv by the end of the century. This concentration is not unprecedented. Data suggest that CO_2 levels were as high as 1,000 ppmv between 30 million and 100 million years ago. The cause is uncertain but geologists speculate it was due to volcanic outgassing, massive decay of vegetation, and metamorphic processes that released carbon from rocks as mountains formed.[22]

Temperature data for about 35 million years ago show a much warmer world. The global mean average temperature was 87.8°F compared with 57.2°F today.[23] Then, as today, warming was amplified in the polar regions. Tropical sea surface temperatures were 95° to 104°F compared to about 86°F today; however, polar sea surface temperatures were 68° to 77°F compared with only 40 degrees today, a temperature range that would mean total loss of Arctic sea ice.[24]

Study of past climates reveals that very high CO_2 levels were reduced to preindustrial levels over tens of millions of years. A return to those levels in a relative eye blink of less than three centuries is unprecedented. A slow, leisurely, temperature rise over millions of years would allow mammals such as the polar bear to evolve traits suited for survival in a warm, ice-free environment. Unfortunately, the change will occur in an evolutionary instant.

TWO OTHER THREATS

Just when Arctic warming threatens their sea ice habitat, polar bears are also being assaulted by modern civilization in other ways. One is the presence of industrial-age pollutants. Southerly winds and ocean currents transport molecular traces of flame retardants, solvents, surfactants, pesticides, metals, and other substances to the Arctic. Many of these chemicals are persistent, meaning their molecular bonds resist breakdown in nature.

[20] Intergovernmental Panel on Climate Change, *IPCC Second Assessment: Climate Change 1995* (Geneva and Nairobi: World Meteorological Organization and United Nations Environmental Programme, 1995), p. 22.

[21] Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report* (New York: IPCC, 2007), p. 72.

[22] Paul N. Pearson, "Increased Atmospheric CO_2 During the Middle Eocene," *Science*, November 5, 2010, p. 763. Trace atmospheric CO_2 levels can be estimated using carbon isotope ratios in organic compounds found in marine algae taken from ancient sediments.

[23] Jeffrey Kiehl, "Lessons from Earth's Past," *Science*, January 14, 2011, p. 158; and National Aeronautics and Space Administration, "GISS Surface Temperature Analysis," at http://data.giss.nasa.gov/gistemp/abs_temp.html, February 20, 2011.

[24] Kiehl, "Lessons from Earth's Past," p. 158.

Of particular concern are dozens of organochlorine molecules, PCBs and DDT are two examples, because they bond with fat molecules. At the top of the Arctic marine food chain, polar bears that depend on fat-rich diets accumulate these organic chemicals in their adipose tissues. Their livers metabolize them, but the metabolites are biologically active and are suspected of interfering with the bear's immune, endocrine, and reproductive systems.[25]

A second intrusion into bear habitat is fossil fuel extraction. The Arctic is enormously rich in oil and natural gas, and activity is increasing. Most production now takes place on land, where networks of roads, pipelines, and well pads laid down in sparsely populated areas increase the number of bear–human interactions.

However, the outer continental shelf in seas north of Alaska holds as much $3 trillion of energy reserves, including 24 billion barrels of oil and 108 trillion cubic feet of natural gas.[26] Therefore, much future activity may move out to sea, bringing with it more noise, ship traffic, and oil spills with uncertain effect on the bears. Other nations will exploit Arctic oceans too. Russia already has a field of 113 trillion cubic feet of gas under development and estimates reserves of 586 billion barrels of oil in the Barents Sea.[27]

For a lease sale off the Alaskan north coast a federal agency estimated the chance of an oil spill of 1,000 barrels or greater was 11 percent. A few years later, for another lease sale, it estimated the chances in the range of 33 to 51 percent.[28] Oil spilled in the Arctic environment would persist. If it occurred in winter, oil might be trapped under the ice until summer thaw. Or oil might collect in cracks and open spaces between the ice floes where polar bears hunt seals. If a bear became coated with oil, its fur would mat and freeze, exposing it to catastrophic heat loss. If the bear ingested a large amount of oil in grooming itself, it would likely be poisoned.

Yet the Arctic holds huge reserves the world could use to meet its heavy energy demands. Nations are unlikely to forgo capitalizing on these reserves absent an as-yet undiscovered will to sacrifice economic welfare for even the most magnificent of species.

THREATENED, NOT ENDANGERED

In 2008 the Fish and Wildlife Service determined that the polar bear was threatened with extinction.[29] The Fish and Wildlife Service is a bureau of 9,000 employees in the Department of the Interior that enforces federal wildlife laws. Among them is the Endangered Species Act, a statute passed in 1973 setting forth procedures for designating, or "listing," such species. The act defines an *endangered* species as one "in danger of extinction throughout all or a significant portion of its range." It also permits listing of a *threatened* species that is "likely to become an endangered species in the future throughout all or a significant portion of its range." Once a species is listed in either category, it is entitled to a great deal of protection. Under threat of civil or criminal penalties, it is illegal to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any individual of the listed species on public or private lands.

The Fish and Wildlife Service listed the polar bear as a threatened species because its Arctic sea ice habitat was declining through its range and the decline was expected to continue. With a current population of perhaps 25,000 the species was not yet in danger of extinction; however, as the extent of sea ice contracted, it was likely to become an endangered species "within the foreseeable future," a time defined as 45 years, or three polar bear generations.

When a species is listed as threatened or endangered the Endangered Species Act requires designation of "critical habitat," a geographically defined area with features essential to its survival. In 2010 the Fish and Wildlife Service set aside 187,157 square miles

[25] See, for example, Melissa A. McKinney, et al., "The Role of Diet on Long-Term Concentration and Pattern Trends of Brominated and Chlorinated Contaminants in Western Hudson Bay Polar Bears, 1991–2007," *Science of the Total Environment* 408 (2010), p. 6211.

[26] U.S. Fish and Wildlife Service, *Economic Analysis of Critical Habitat Designation for the Polar Bear in the United States*, draft report (Cambridge, MA: Industrial Economics Incorporated, March 15, 2010), p. ES-2.

[27] Scott G. Borgerson, "Arctic Meltdown: The Economic and Security Implications of Global Warming," *Foreign Affairs*, March 2008, p. 63.

[28] U.S. Fish and Wildlife Service, "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Polar Bear (Ursus maritimus) Throughout Its Range; Final Rule," 73 FR 28289, May 15, 2008. The agency was the Bureau of Ocean Energy Management, Regulation and Enforcement.

[29] Ibid., at 73 FR 28212.

encompassing barrier islands and spits along the Alaskan coast, denning areas up to 20 miles inland, and sea ice extending out over the continental shelf to waters up to 1,000 feet deep.[30] About 95 percent of the habitat area is ocean, only 5 percent falls on land. This designated space, of course, protects only individuals of the two bear populations in U.S. territory.

There was major opposition to both the bear's listing and to setting aside critical habitat. Both the energy industry and the State of Alaska objected. Once critical habitat is defined, federal agencies, corporations, and individuals are prohibited from adversely modifying or destroying it. Although energy production can continue, oil and gas companies now have to take precautions not to disturb bears. They are required to study the areas they work in to see if bear habitat exists and make plans to avoid altering it. This requires hiring biologists to search for nearby bear dens and see if they are occupied. All this can delay or prevent production or require rerouting helicopters, pipelines, and roads. Biological assessments cost $50,000 to $300,000 per site. Energy companies also fear lawsuits by environmentalists. At the time critical habitat was designated, the State of Alaska estimated that for a hypothetical North Slope oil field a one-year delay would have a $203 million adverse regional economic impact and a five-year delay would cause a $2.6 billion loss.[31]

The Fish and Wildlife Service is required to set up a recovery plan for each listed species setting out the actions necessary to save it from extinction. For the polar bear this would mean actions to halt the loss of sea ice, nothing less than a massive global reduction in greenhouse gas emissions, and an immediate one, since many greenhouse gases will remain in the atmosphere for years, continuing to cause terrestrial heat buildup long after emissions cease. The agency recognizes that it has no legal authority to do this.

> While we recognize that climate change will negatively affect optimal sea-ice habitat for polar bears, the underlying causes of climate change are complex global issues that are beyond the scope of the [Endangered Species] Act.[32]

Obviously, most polar bear habitat lies outside the reach of the statute. The Fish and Wildlife Service has no jurisdiction over CO_2 emissions from a refinery in Lagos or a steel mill in Brussels. An international authority is required. So far the world has taken little action to reduce greenhouse gas emissions. Efforts to negotiate comprehensive regulations have repeatedly failed. The two most salient efforts, the Kyoto Protocol and a European emissions trading scheme, are better valued for their precedent than for their impact on atmospheric chemistry. The United States has avoided both international commitments and meaningful national reductions.

Nevertheless, a Fish and Wildlife Service field office in Alaska has a five-year conservation plan for polar bears in the critical habitat.[33] It protects maternal dens by prohibiting oil and gas drilling within one mile and setting a minimum altitude for airplane overflights. Barge operators who ply Alaskan waters are trained to avoid swimming bears. Other actions are designed to reduce lethal bear–human encounters. Town garbage dumps must be adequately fenced. Tourists are given safety guidelines. Funds are granted for village bear patrols by officers equipped with guns that fire crackershells and beanbags.

FADING AWAY

It is a small beginning indeed. Other nations have not galvanized themselves even this much. In Norway a law protects some land habitat from development. In Russia the bears are listed as a "protected" species when they are in areas with national park-like designations. And in Canada the bear is listed as a "species of special concern" under its Species at Risk Act, but this is a less urgent classification than the bear's "threatened" listing under the U.S. Endangered Species Act and requires no stringent measures.

Currently there are 1,372 species listed as threatened or endangered under the Endangered Species Act–579 animals and 793 plants. A listing is ominous. Only 46 species have ever been delisted despite

[30] U.S. Fish and Wildlife Service, "Designation of Critical Habitat for the Polar Bear (Ursus maritimus) in the United States; Final Rule," 75 FR 76086, December 7, 2010.

[31] Ibid., at 76104-76107.

[32] Ibid., at 76116.

[33] U.S. Fish and Wildlife Service, *Spotlight Species Action Plan: Polar Bear,* Anchorage, Alaska, RPN-5C, undated.

almost four decades of regulatory protection. Of these, nine species are extinct. Another 19 have recovered. The rest were taken off for a variety of reasons, most because they had been misclassified as a separate species.[34] The polar bear will be on the list for a long time. Eventually it will come off, for one reason or another.

[34] U.S. Fish and Wildlife Service, "Species Reports" Environmental Conservation Online System, at http://ecos.fws.gov/tess, February 15, 2011.

Questions

1. Do you believe that polar bears are endangered as a species now or in the future? Why or why not?
2. What is the value of the polar bear to the United States? To humanity?
3. Is it important that humanity act to save the polar bear? Why or why not?
4. Can the bear be saved? What actions are required?
5. Should more be done now? If so, what is feasible?
6. Would the economic and noneconomic benefits of saving the bear exceed the costs?