Sacred fir (*Abies religiosa*), often called oyamel, is a large conifer tree, whose dense, dark-green beautiful crown resembles that of Douglas-fir. Sacred firs are found only in high altitude sites (from about 8,000 to about 12,000 ft.) in Mexico, mostly along the Trans-Mexican Volcanic Belt, a formation that includes the majestic and snow-covered Popocatépetl and Iztaccíhuatl volcanoes.

Eastern migratory Monarchs spend the winter amidst the dense and mature populations of sacred firs located within the Monarch Biosphere Reserve (MBR) located at the borders of the Mexican states of Michoacán and México (see map, page 15).

Here, the butterflies take advantage of the umbrella and blanket effects of the sacred fir forest canopy and branches, packing together in colonies where butterflies cluster side-by-side on the stems and branches to prevent mortality during cold and rainy winter nights. It is clear that, if we want to protect the migratory Monarchs, we must protect the sacred fir populations inside the MBR.

Generation after generation of Monarchs have overwintered in the sacred fir forests now protected inside the MBR. Amazingly, the Monarch generation that arrives at the MBR has never been there before. Somehow the information required to navigate from Canada and the United States to the MBR is genetically passed from one generation to the next. This incredible natural phenomenon might make it difficult for Monarchs to adapt to the effects of global climatic change.

Averaging several climatic models and greenhouse-effect gas emission scenarios, we have projected that, in Mexico, there will be a temperature increase of 6.7 °F and a precipitation decrease of 18.2% by the end of the century. That will mean more heat and drought stress for the trees. More stress means that the trees will have less natural defenses to prevent attacks of insects and diseases; and more successful attacks means that more trees will become unhealthy and then die. Massive climate-change related deaths of trees have been documented in many parts of the world recently: e.g., Pinyon Pine in the southwestern United States and Quaking Aspen in the Rocky Mountains of the U.S. and Canada.

Our concern is that forest decline due to climatic change eventually will affect the sacred fir forest inside the MBR. The near exclusive use of these trees as Monarch winter roosts makes it difficult to envision survival of overwintering butterflies at this site without the trees. Increasingly, observers see sacred firs inside the MBR that exhibit signs of dieback, apparently due to drought stress in the changing climate (see top right photo, pg. 17).

We developed a mathematical model that allows us to predict the geographic distribution of the climate suitable for sacred firs, and then project where that climate will be in the future (decades centered in years 2030, 2060 and 2090). We did that by comparing the contemporary climate (averaging 30 years, from 1961 to 1990) at the sites where there is natural distribution of sacred firs, with the climate at sites where sacred firs are absent. Then, we used GIS software to construct maps indicating areas where the current climate is suitable for sacred firs, even if sacred firs are not actually there. Finally, we repeated the mapping process, but now used climate projections for the decades centered in years 2030, 2060 and 2090.

The results of this research project that the climate suitable for sacred firs will occupy an area that shrinks as time passes, ascending in altitude. For example, the contemporary climate allows growth of healthy sacred firs that now are found at about 9,842 ft. in elevation but the same climate will occur at 10,827 ft. in 2030. In other words, the climate will move about 1000 ft. upward by 2030. The problem is that at higher and higher altitudes, the mountains have less and less surface area, until we finally reach the mountain summit. At that point, there is no more land available with a climate suitable for sacred firs (see map, page 16).

It is extremely troubling that, by year 2090, we project that there will not be a single square mile of climate suitable for sacred firs within the MBR (no red pixels inside the MBR area on the map of pg. 16; each pixel ~ 0.4 mile²). We call this process a decoupling between the tree populations and the climate for which they are adapted. The tree populations stay, but the appropriate climate moves away, climbing the mountains, to higher altitudes. The trees left behind by the moving climate then start suffering the stresses imposed by a new warmer and dryer climate, become debilitated and more easily subject to the attacks of insects and diseases, and eventually they die.

Can sacred fir populations “fix” the problem by themselves, moving, by natural means, altitudinally upwards and keeping pace with the moving appropriate climate? The answer plainly is no. The natural migration processes of sacred firs, depending upon wind dispersal of seeds, establishing new seedlings that then grow until they reach sexual maturity, and reproduce again to release a new