Letter from the Desk of David Challinor
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During the summer of 1958, my family and I lived in Seeshaupt, then a small Bavarian town at the south end of Starnberger See. It was an hour's commute by train and bicycle to the Forestry School at the University of Munich, where I was studying silviculture. Of all the Bavarian forest districts I visited that summer, the most interesting one was in the Spessart Mountains between Frankfurt and Wurtzburg. This forest is famous for its large stands of slow growing oak. The trees I saw were seldom more than 45 cm (18 in) dbh (diameter breast high), rather widely spaced and growing in a nutrient-poor sandy soil. Their slow growth, often with as many as 20 rings to the inch, resulted in extremely dense wood, ideal for veneer. At that time, German foresters were still planting oak there on a 300 to 400 year rotation! The current high value of these stems was the unwitting result of the medieval Wurtzburg bishops' penchant for hunting boar on horseback in the forest. The Bishops' servants pruned the oaks high enough so that a rider would not hit his/her head on a branch. That pruning plus the villagers' persistent practice of lopping off lower branches for fuel made the bottom 10 feet of the trunk virtually knot free—a perfect condition for veneer logs. Exposure to these ancient oaks so early in my forestry career fired my curiosity about this genus and led me eventually to study red oak as a significant part of my Ph.D. research. This month's letter will share what I have since learned about these magnificent trees.

In fairness, all oaks do not develop into forest giants. There are many species growing in dry parts of the world that seldom exceed a meter in height, and as many south Texas ranchers know, they are hell on horses' forelegs and any rider foolish enough to be chaps-less. But the large oaks have a special appeal to me. Europe, north of the Alps, Pyrénées, and Carpathians has only two species, both in the white oak group and none in the red. In eastern North America, however, where the mountains run north and south, we are blest with eight large white oak species and at least nine red oaks. A major reason for this bounty is that unlike in Europe, trees could migrate south during glacial times and not be trapped against the mountains.

The common characteristic of all oaks is that they produce acorns, but usually not every year. The reasons for this intermittent production are not fully understood and will be considered later. Fruitary years are called mast years—mast being an Old English term for nuts on the ground—and such largesse was welcomingly exploited by medieval peasants who drove their swine herds through the oak forests to gorge and fatten on acorns. Illustrations of these mast forests from the XV century depict oak trees pruned high with little underbrush evident, perhaps as a result of overbrowsing by domestic stock. The open forest floor probably helped herders keep their livestock in view and made it hard for large predators to hide.

In the new world the plethora of oaks undoubtedly had a greater effect on wildlife populations than they did on the scattered settlers in the hardwood forests of eastern North America. Mast is a favored food of deer, turkey, woodchuck, squirrels and a host of insects, especially the acorn weevil. Fortunately for me, the fall of 1960 was a mast year in New Haven, CT, because I needed a lot of oak seedlings for my dissertation experiment. Many streets near Yale's Forestry School were lined with mature red oak from which I collected bushels of acorns. To ensure viability, I poured the acorns into a large tub of water. Weevil-infested acorns floated because they were hollow. Weevil larvae had eaten much of the acorn's two cotyledons (fleshy, yellow half-spheres containing essential nutrients needed for the germinating seedling). City-grown acorns are less infested than rural ones; fattened weevil larvae emerging from infested acorns cannot overwinter in the ground because so little soil is available among paved streets and sidewalks.

An example of how a mast year affects wildlife in New England is seen in the subsequent rapid rise of white-footed mice and deer—two major acorn consumers. The more mice and deer, the more hosts are available for seed ticks—carriers of Lyme disease. A few years ago after six or seven people at the Smithsonian's Environmental Research Center (SERC) on Maryland's Chesapeake western shore were struck with Lyme disease, the state allowed SERC to have a controlled deer hunt on its 3,500 acres and hunters harvested a few score deer of both sexes. High mouse populations following a mast year can be beneficial to hardwood forest managers, because white-footed mice readily eat the silvery gypsy moth eggs deposited on the trunks of oaks and other hardwoods. Oak leaves are a preferred food of gypsy moth larvae.

Scientists are still not clear exactly what triggers a mast year. The phenomenon is by no means confined to the Fagaceae (oaks, beech and chestnuts), but also occurs in bamboo in a more regular fashion. Some bamboo species flower every 100 years no matter where in the world they are growing. Synchronous flowering results in so much seed production that seed eaters can consume only a negligible fraction of the crop, assuring that there will be a large surplus to germinate. Unfortunately, unlike oak, bamboo dies after seeding with profound effects on bamboo eaters such as the giant panda.

Masting is a population phenomenon. That is, all the oaks in a large area somehow determine to flower both synchronously and abundantly. The fruiting season following the high energy output of a mast year often results in few or almost no acorns. One theory proposes that mast years are controlled by climate, e.g. warm, wet growing seasons, which provide the extra nutrients that enable a tree to flower abundantly. Such ideal growing conditions vary yearly and geographically and thus might account for the irregular sequence and intensity of mast production. However, this does not seem to be the primary reason because variations in temperature and rainfall during a growing season do not correlate with the predicted size of the local acorn crop. What has been learned by careful measurements is that trees grow hardly at all during mast years, because their energy is devoted to fruiting rather than vegetative growth. Following a mast year, the increase in height and diameter resumes. This ability of oaks to switch energy resources may be a reaction to some yet unidentified environmental condition.

Still to be determined is precisely what role pollen production may play in mast production. Among fagaceae, wind pollination is the norm; thus synchronous flowering should ensure that minimal pollen is wasted. New evidence is accumulating, however, that even among wind-pollinated trees, pollen quantity may be limited. In an attempt to find an answer, Koenig and Knops, scientists at Berkeley and University of Nebraska respectively, started their massive oak survey in California in 1994. They estimated the acorn crop at 19 sites spread throughout the state on > 1,000 trees of nine acorn-producing species. After 11 years of measuring, they found acorn production to be synchronized in just about every California blue oak (*Quercus douglasii*)—between 100 and 200 million trees.

What actually triggers synchronous flowering is still elusive. Broad weather patterns now seem to be the most promising explanation. A recent analysis of masting phenomenon in a dipterocarp forest in Borneo showed a correlation between fruiting in canopy trees and La Nina events of ENSO (El Nino Southern Oscillation). Dipterocarps are the dominant canopy trees in Southeast Asian forests and many are valuable commercially. ENSO events occur every three or four years with occasional longer intervals and scientists have thought they primarily affect the earth's lower latitudes, but now ENSO appears to alter weather patterns in a much wider area. If indeed ENSO events affect fruiting in California's blue oaks as well as New England's red and white oaks, we can begin to appreciate how powerful the temperature dynamics of the world's oceans are in affecting such seemingly unrelated phenomenon as mast years. We have learned of the peril that the recent warming of the mid-Atlantic has demonstrably increased the number of early hurricanes in the Caribbean that strike our shores.

It is hard to imagine what more direct evidence is needed to convince the Bush Administration of the serious consequences of ignoring the Kyoto protocol. Even though the degree of human activity contributing to global warming is not known precisely, it is time to seriously and drastically cut burnt fuel emissions. This reduction might possibly dampen the number and force of hurricanes, as well as affect mast years and their concomitant relation to Lyme disease and gypsy moth defoliation of hardwood forests. Trees and humans are all part of the same global system and to preserve our environment we must protect and nurture the entire globe. It is past time for piecemeal efforts; we owe it to our grandchildren and their progeny to safeguard the environment.

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P.S. Much information for this letter came from Koenig, W.D. and J.M.H. Knops. (2005) The Mystery of Masting in Trees. *American Scientist* 93 (4): 340-347