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MONITORING THE HEARTBEAT OF FORESTS FROM SATELLITES

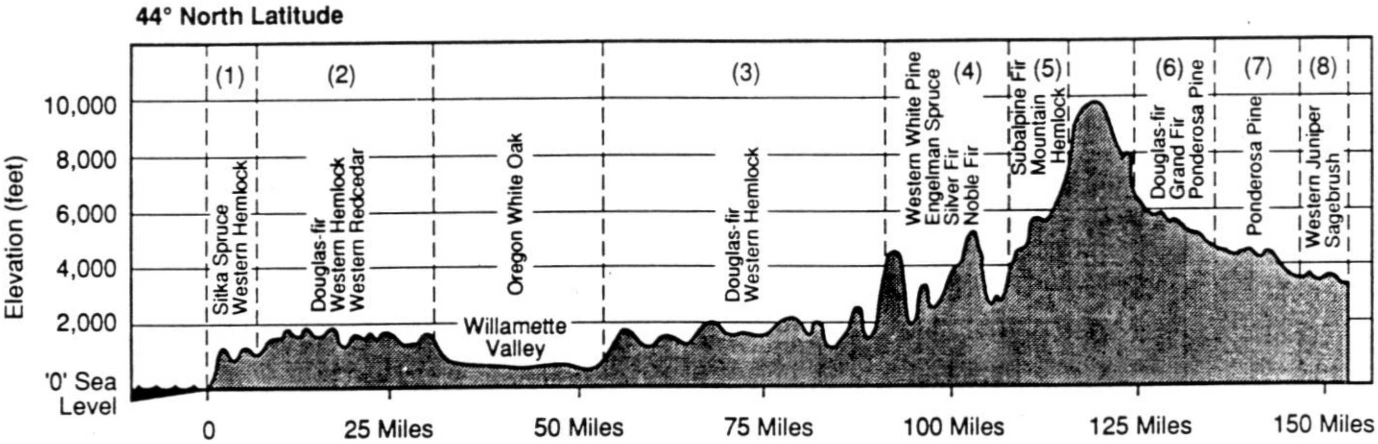

Figure 1. A steep climatic gradient runs across two mountain ranges in western Oregon from the Pacific Ocean inland 150 miles to a high, cold desert. The numbers refer to eight major vegetation zones located along the transect. After Franklin and Dyrness (1973).
Illustration provided by author.

Anyone who watched the Olympic Games televised from Korea did so from signals bounced off communication satellites. Our daily weather reports on television also use satellite coverage to spot hurricanes building up off the Gulf Coast or blizzards moving across the Great Plains. Satellites play many important roles because they can scan the earth continuously. These "eyes in the sky" record the greening of fields and forests in the spring and later the gold and red colors of ripening grain and autumn foliage.

Satellites are especially important now as we recognize that human activities seem to be affecting global climate. Our climate is projected to become warmer, increasing the number of days in the growing season. At the same time, the dangers of persistent drought and extensive wildfires may grow. As the climate changes it will affect the plants in fields and forests around the world.

To get some idea of how climate affects vegetation today, we can view the patterns of activity in the forests and fields of regions where climate changes abruptly. In North America the Pacific Northwest offers a wide range in climate from cold deserts covered with sagebrush and juniper woodlands to a coastal fog-belt clothed by rain forests of Sitka spruce and western hemlock (Fig. 1).

The National Aeronautic and Space Administration (NASA) is aiming satellite sensors on a transect across Oregon to see how well the structure, growth, and health of the vegetation can be characterized. Although most of the forests in Oregon are composed of evergreens, they still show seasonal changes in activity. The more favorable the environment for growth, the more needles a forest produces and the longer these needles remain active capturing energy from sunlight through the process of photosynthesis. The green pigment, chlorophyll, found in needles and other leaves, absorbs visible light in certain color bands that distinguish plants from anything else on earth. When there is a drought, the chlorophyll content in vegetation is reduced. Repeated drought prevents trees from growing close together and changes the composition of forests in Oregon from firs and hemlocks to pine or juniper.

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Forest ecologists, working with scientists from NASA, are using satellites to estimate how much photosynthesis occurs across the climatic gradient in Oregon. The amount of chlorophyll pigment in the vegetation is assessed on the clearest day each month for eight different kinds of forests (Fig. 1). By keeping track of the extent of cloudy weather each month and how brightly the sun shines, the amount of energy absorbed by the chlorophyll can be summed for the year. This satellite-derived index compares well with the measured growth of forests across the climatic gradient.

New studies involve the testing of different kinds of sensors carried in helicopters, conventional aircraft, and high-flying spy planes. Thermal (heat) sensors that located the fire front in Yellowstone National Park last summer will be used to measure the temperature increase in the needles of forests under drought stress. With radar instruments that can see through dense clouds, scientists will try to estimate the size of trees. Other sensors capable of measuring the starch and protein content of leaves will be flown over fertilized and unfertilized patches of forests. Together these new instruments will provide the basis for future satellites to pick up the first signs in the earth's vegetation of the effects of climatic change and to distinguish these changes from those induced by regional scale pollution, land conversion, fire, or insects.

To begin to understand the operation of forests and other types of vegetation has taken many years of effort by ecologists and other biologists. These scientists now join forces with engineers and physicists to help tailor satellites to the task of monitoring the heartbeat of forests, fields, and other vegetation across the surface of the earth.

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