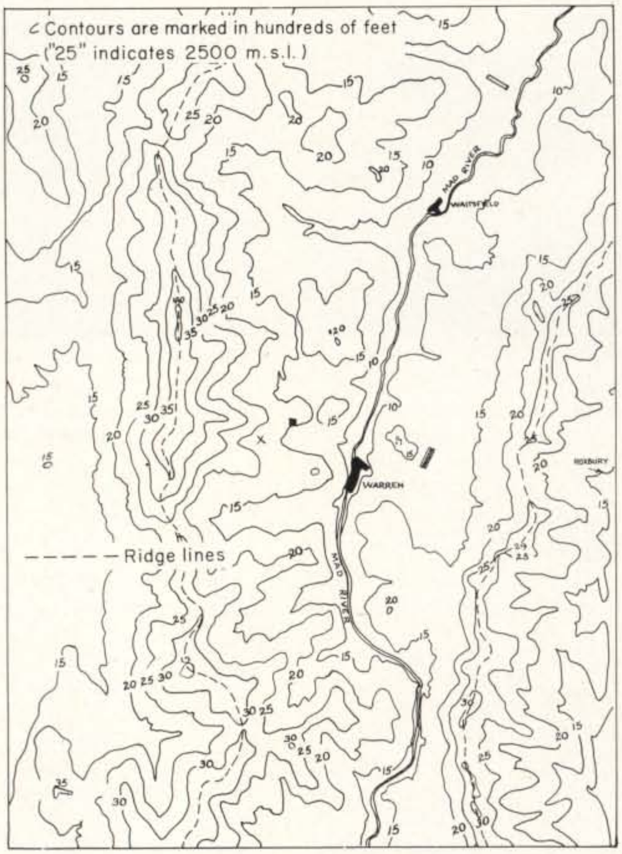
THE SUGARBUSH WAVE

ALAN C. BEMIS

We have been soaring the Sugarbush Wave in Vermont for four years now. In 1963 and 1964 we launched from Estey Field in Waitsfield and in 1965 moved to the new Warren-Sugarbush Airport. As of January 1967, at least 18 Diamond altitude gains had been made there. The news has spread widely and several good articles have appeared on this excellent site.



Sugarbush Soaring Area
Legend

– Warren-Sugarbush Airport – Estey Airpark (closed)
◆ – Sugarbush Inn X – Sugarbush ski area parking lot

FIGURE 1

It seems high time, therefore, that we attempted an analysis of the structure of this wave, and a comparison with other mountain lee waves. As a meteorologist and one who has logged 70 hours of wave soaring at Sugarbush and in the west, I will have a try at it.

A number of very complete and accurate mountain wave studies have, of course, been made by others and my objective here is to apply the results of these to Sugarbush. Most applicable is Gerbier and Berenger's "Experimental Studies of Lee Waves in the French Alps" (Quarterly Jour. Roy. Met. Soc., Vol. 87). Observations were made with radiosonde, radar, zero-lift ballons and well-instrumented gliders and powered aircraft. The analysis is carefully done and complete and I commend this article to everyone interested in lee waves. SSA's American Soaring Handbook, Volume Six should be studied, too.

The Hudson River-Lake Champlain Valley on Vermont's west border runs almost true north-south for some 300 miles. The mountain ridges east of the valley are parallel to it. In particular, the ridge used by the Mad River, Glen Ellen and Sugarbush ski areas is high for Vermont and well-formed for mountain wave development. This is clear from Fig. 1. Fig. 2 shows a cross-section of the mountains and the air-flow when both have been smoothed and idealized to represent an average east-west cross-section. By "average" I mean an average in time with respect to air-flow, and given a five-mile north-south average in space of the land profile centered on Sugarbush Inn.

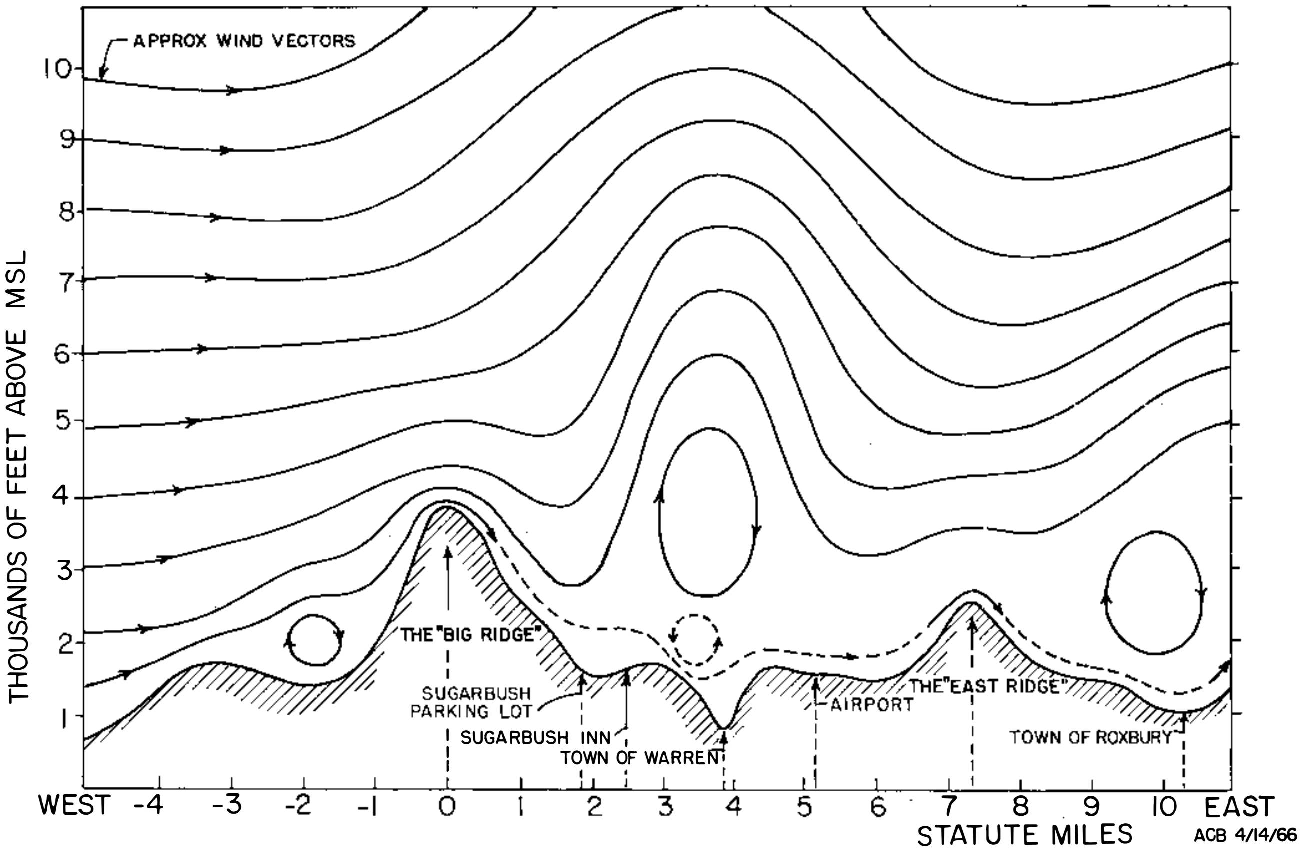
The westerly winds flow smoothly across Lake Champlain. The mountains present a barrier of almost perfect shape for lee wave development so that the idealized wave form shown in Fig. 2 is often found in practice. My own log records 12 wave flights in which I went to altitudes of from 12,000 to 19,000 ft. directly over Sugarbush Inn. But substantial variations in the wave form do occur. The best lift is found from as far west as the Sugarbush parking lot to as far east as the airport.

Lift in the secondary is sometimes quite good but I have never been over 12,000 ft. in it. The secondary is found anywhere from just east of the airport to as far as Roxbury. When wave length is short it is quite a thrill to take a position over the parking lot at 3,000 ft. M.S.L., facing right into the big ridge (only a mile away horizontally, where it seems one must be in strong sink) and watch the rate of climb increase and the altimeter needles wind joyfully upward.

Quite a few wave flights have been made at Sugarbush after gaining altitude in thermals or by ridge soaring, but airplane tow is usually essential. Conditions on tow vary. When surface winds are high and surface air unstable, gustiness on the ground and turbulence in the rotor can be severe, but sometimes nearly all the wind is aloft, ground handling a cinch and only light turbulence in the rotor area. The wave itself is smooth as silk. One can trim for the desired airspeed and fly hands off. The only turbulence I can remember in the wave occurred when climbing through a wind shear zone and that was just a wiggle or tow.

Wave development requires stable air and at least 15 knots of wind from a direction within 30° of the perpendicular to the ridge, i.e., from 240° to 300° true. Obviously 20 to 50 knots is much better and 70 knots at 20,000 ft. has been observed. Wave length almost always increases with height and amplitude usually decreases. If velocity increases with height, as is most common, the zone of best lift is over the same ground point all the way up in the primary. Both the wave length increase with height and the amplitude decrease cause the lift to drop off with height, and finally limit the altitude gain. This type of wave structure is the commonest at most locations, I believe.

If the wind is strong and nearly constant all the way up from the top of the ridge, the zone of best lift moves forward into the wind with increasing altitude. Again wave length increases and amplitude decreases



SUGARBUSH WAVE STRUCTURE

FIGURE 2

with height, but this wind structure creates the simplest wave form and maintains good amplitude to the highest altitudes. This appears to be the set-up for Diamond altitudes.

If there is a sharp increase in wind speed within a shallow layer (usually at a temperature inversion) there will be turbulence in the shear layer and wave motion above it, but the wave structure will be quite different from that below. If the wind decreases sharply with altitude the wave motion disappears above that level. The effect of a change of direction with altitude varies widely depending on the amount of the change, the stability of the shear layer and so forth. Much direction change has always been bad news in my experience.

In the Southwest the air is so dry one can do much wave soaring with no clouds. We have some of this in New England, too, but on many days the cloud cover is continuous, making safe wave soaring impossible for most of us. Flying on top under these conditions one sees beautiful wave form on the cloud tops, but wave motion does not seem to extend very high above the clouds. As drier air moves in the windows open up in the wave troughs and one can climb rapidly up through the leeward side of the window.

Cloud forms not only mark the waves for us, but also add much to the beauty of flight. The most common wave clouds at Sugarbush are the long bands that form parallel to the ridges with bases close to ridge-top level and tops at about 8,000 ft. Often textbook lennies form, too, at 15,000 to 20,000 ft., but I have seen the very high ones more often in the lee of Mt. Washington than I have at Sugarbush.

Because there is more wind in winter there is more wave. Day after day in winter, beautiful wave clouds hang over the valley while the winter winds pour through them. There are many days of wave in the spring and fall, too, but in summer thermal soaring predominates.

Sugarbush is not the place to make absolute altitude records. The ridge high point is 4,040 ft. above Lake Champlain, so Diamond altitude gains should be common. For an eastern U. S. absolute altitude record go to Mt. Washington, New England's high point. So far the highest altitudes have been flown there. (See "Waves, East & West," *Soaring* Feb. 1967.) However, the Sugarbush ridge with its near perfect shape and orientation produces wave more frequently than many other sites and is ideal on most counts. Tehachapi, Colorado Springs and Mt. Washington cannot claim all the following features. The airport is only three miles from the primary and 2,000 ft. below usual release so that towplane round trips are only 10 minutes. Low-points down to 3,000 ft. M.S.L. are possible. Wave "drop-outs" make it back to the airport, but the Sugarbush golf course, right under the wave, is a comforting sight sometimes and there are good emergency fields all over the valley. For cross-country flights one should be able to ride the wave south to western Connecticut, or take-off downwind on a northwester for Cape Cod. Plymouth, Mass. (short of the Cape and also a gliderport) is just 186.4 miles from Warren-Sugarbush! No one has tried this *yet*. As Ballinger remarked, "It is too beautiful right here."