CHAPTER 10
Soaring Techniques

Soaring flight, maintaining or gaining altitude rather than slowly gliding downward, is the reason most glider pilots take to the sky. After learning to stay aloft for two or more hours at a time, the urge to set off **cross country** often overcomes the soaring pilot. The goal is the same whether on a cross-country or a local flight—to use available updrafts as efficiently as possible. This involves finding and staying within the strongest part of the updraft. This chapter covers the basic soaring techniques.

In the early 1920s, soaring pilots discovered the ability to remain aloft using updrafts caused by wind deflected by the very hillside from which they had launched. This allowed time aloft to explore the air. Soon afterward, they discovered thermals in the valleys adjacent to the hills. In the 1930s, mountain waves, which were not yet well understood by meteorologists, were discovered leading pilots to make the first high altitude flights. Thermals are the most commonly used type of lift for soaring flight, since they can occur over flat terrain and in hilly country. Therefore, we will begin with thermal soaring techniques.

As a note, glider pilots refer to rising air as lift. This is not the lift generated by the wings as was discussed in Chapter 3—Aerodynamics of Flight. The use of this term may be unfortunate, but in reality it rarely causes confusion when used in the context of updrafts. This chapter refers to lift as the rising air within an updraft and sink as the descending air in downdrafts.

THERMAL SOARING

When locating and utilizing thermals for soaring flight, called thermalling, glider pilots must constantly be aware of any nearby lift indicators. Successful thermalling requires several steps: locating the thermal, entering the thermal, **centering** the thermal, and finally leaving the thermal. Keep in mind that every thermal is unique in terms of size, shape, and strength.

In the last chapter, we learned that if the air is moist enough and thermals rise high enough, cumulus clouds, or Cu (pronounced 'q') form. Glider pilots seek Cu in their developing stage, while the cloud is still being built by a thermal underneath it. The base of the Cu should be sharp and well defined. Clouds that have a fuzzy appearance are likely well past their prime and will probably have little lift left or even sink as the cloud dissipates. [Figure 10-1]

Judging which clouds have the best chance for a good thermal takes practice. On any given day, the lifetime of an individual Cu can differ from previous days, so it becomes important to observe their lifecycle on a particular day. A good looking Cu may already be dissipating by the time you reach it. Soaring pilots refer to such Cu as rapid or quick cycling, meaning they form, mature, and dissipate in a short time. The lifetime of Cu often varies during a given day as well; quick cycling Cu early in the day will often become well formed and longer lived as the day develops.

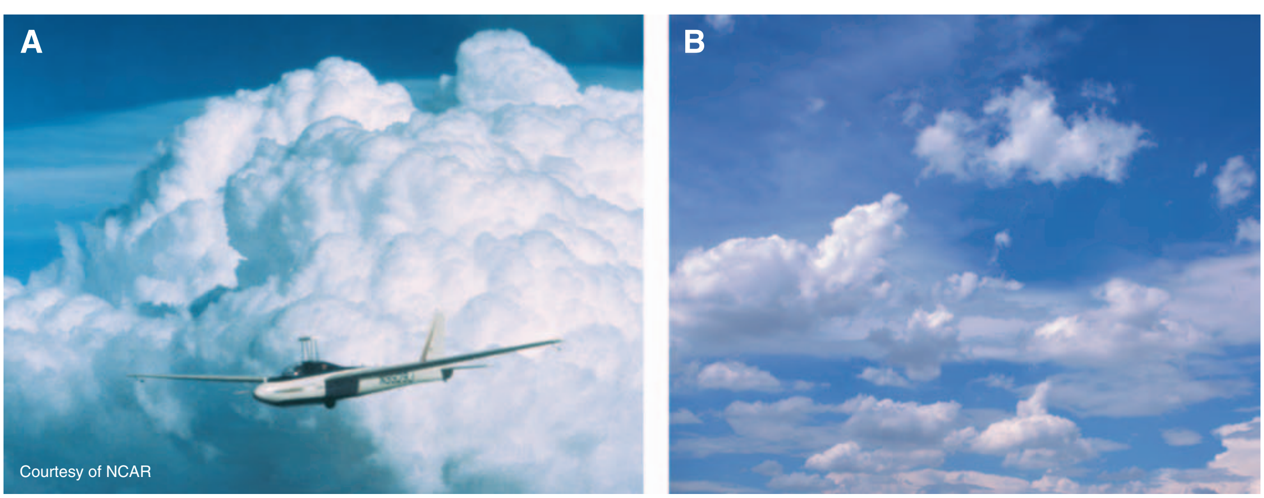

Figure 10-1. Photographs of (A) mature cumulus likely producing good lift, and (B) dissipating cumulus.

Sometimes Cu cover enough of the sky that seeing the cloud tops becomes difficult. Hence, glider pilots should learn to read the bases of Cu. Generally, a dark area under the cloud base indicates a deeper cloud; therefore, a higher likelihood of a thermal underneath. Also, several thermals can feed one cloud, and it is often well worth the deviation to those darker areas under the cloud. At times, an otherwise flat cloud base under an individual Cu has wisps or tendrils of cloud hanging down from it, producing a particularly active area. Cloud hanging below the general base of a Cu indicate that that air is more moist, and hence more buoyant. Note the importance of distinguishing features under Cu that indicate potential lift from virga. Virga is rain or snow from the cloud base that is not yet reaching the ground and often signals that the friendly Cu has grown to cumulus congestus or thunderstorms. [Figure 10-2] Another indicator that one area of Cu may provide better lift is a concave region under an otherwise flat cloud base. This indicates air that is especially warm, and hence more buoyant, which means stronger lift. This can cause problems for the unwary pilot, since the lift near cloud base often dramatically increases, for instance from 400 to 1,000 (fpm). When trying to leave the strong lift in the concave area under the cloud, pilots can find themselves climbing rapidly with cloud all around—another good reason to abide by required cloud clearances.

After a thermal rises from the surface and reaches the **Convective Condensation Level (CCL)**, a cloud begins to form. At first, only a few wisps form. Then the cloud grows to a cauliflower shape. The initial wisps of Cu in an otherwise blue (cloudless) sky indicate where an active thermal is beginning to build a cloud. When crossing a blue hole (a region anywhere from a few miles to several dozen miles of cloud-free sky in an otherwise Cu-filled sky), diverting to an initial wisp of Cu is often worthwhile. On some days, when only a few thermals are reaching the CCL, the initial wisps may be the only cloud markers around. The trick is to get to the wisp when it first forms, in order to catch the thermal underneath.

Lack of Cu does not necessarily mean lack of thermals. If the air aloft is cool enough and the surface temperature warms sufficiently, thermals will form whether or not enough moisture exists for cumulus formation. These blue or dry thermals, as they are called, can be just as strong as their Cu-topped counterparts. Glider pilots can find blue thermals, without Cu markers, by gliding along until stumbling upon a thermal. With any luck, other blue thermal indicators exist, making the search less random.

One indicator of a thermal is another circling glider. Often the glint of the sun on wings is all you will see, so finding other gliders thermalling requires keeping a good lookout, which glider pilots should be doing anyway. Circling birds are also good indicators of thermal activity. Thermals tend to transport various aerosols, such as dust, upward with them. When a thermal rises to an inversion it disturbs the stable air above it and spreads out horizontally, thus depositing some of the aerosols at that level. Depending on the sun angle and the pilot's sunglasses, haze domes can indicate dry thermals. If the air contains enough moisture, haze domes often form just before the first wisp of Cu.

On blue, cloudless days, gliders and other airborne indicators are not around to mark thermals. In such cases, you must pay attention to clues on the ground. First, think about your previous flight experiences. It is worth noting where thermals have been found previously since certain areas tend to be consistent thermal sources. Remember that weather is fickle, so there is never a guarantee that a thermal will exist in the same place. In addition, if a thermal has recently formed, it will take time for the sun to reheat the area before the next thermal is triggered. Glider pilots new to a soaring location should ask the local pilots about favored spots—doing so might save the cost of a tow. Glider pilots talk about **house thermals**, which are simply thermals that seem to form over and over in the same spot or in the same area.

Stay alert for other indicators, as well. In drier climates, **dust devils** mark thermals triggering from the ground. In hilly or mountainous terrain, look for sun-facing slopes. Unless the sun is directly overhead, the heating of a sun-facing slope is more intense than that over

Figure 10-2. Photographs of (A) cumulus congestus, (B) cumulonimbus (Cb), (C) virga.

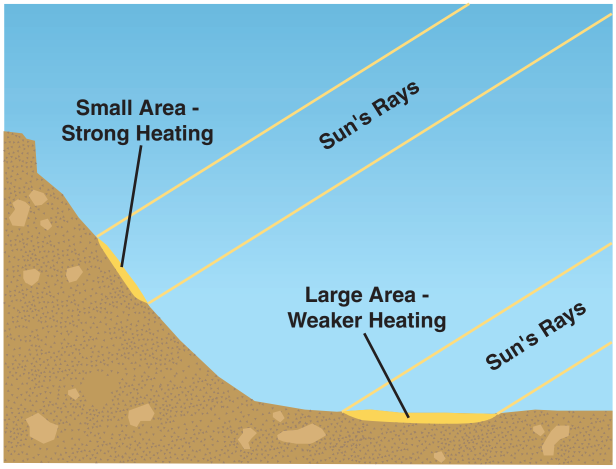

Figure 10-3. Sun's rays are concentrated in a smaller area on a hillside than on adjacent flat ground.

adjacent flat terrain because the sun's radiation strikes the slope at more nearly right angles. [Figure 10-3] Also, cooler air usually pools in low-lying areas overnight; therefore, it takes longer to heat up during the morning. Finally, slopes often tend to be drier than surrounding lowlands, and hence tend to heat better. Given the choice, it usually pays to look to the hills for thermals first.

Whether soaring over flat or hilly terrain, some experts suggest taking a mental stroll through the landscape to look for thermals. Imagine strolling along the ground where warmer areas would be found. For instance, walking from shade into an open field the air suddenly warms. A town surrounded by green fields will likely heat more than the surrounding farmland. Likewise, a yellowish harvested field will feel warmer than an adjacent wet field with lush green vegetation. Wet areas tend to use the sun's radiation to evaporate the moisture rather than heat the ground. Thus, a field with a rocky outcrop might produce better thermals. Rocky outcrops along a snowy slope will heat much more efficiently than surrounding snowfields. Though this technique works better when at lower altitudes, it can also be of use at higher altitudes in the sense of avoiding cool-looking areas, such as a valley with many lakes.

Wind also has important influences not only on thermal structure, but on thermal location as well. Strong winds at the surface and aloft often break up thermals, making them turbulent and difficult or impossible to work at all. Strong shear can break thermals apart and effectively cap their height even though the local sounding indicates that thermals should extend to higher levels. On the other hand, as discussed in Chapter 9—Soaring Weather, moderately strong winds without too much wind shear will sometimes organize thermals into long streets, a joyous sight when they lie along a cross-country course line. [Figure 10-4]

In lighter wind conditions, consideration of thermal drift is still important, and search patterns should become "slanted." For instance, in Cu-filled skies, glider pilots need to search upwind of the cloud to find a thermal. How far upwind depends on the strength of the wind, typical thermal strength on that day, and distance below cloud base (the lower the glider, the further upwind the gliders needs to be). Add to this the fact that wind speed does not always increase at a constant rate with height, and/or the possibility that wind direction also can change dramatically with height, and the task can be challenging.

Wind speed and direction at cloud base can be estimated by watching the cloud shadows on the ground. With all the variables, it is sometimes difficult to estimate exactly where a thermal should be. Pay attention to where thermals appear to be located in relation to clouds on a given day, and use this as the search criteria for other clouds on that day. If approaching Cu from the downwind side, expect heavy sink near the cloud. Head for the darkest, best defined part of the cloud base, then continue directly into the wind. Depending on the distance below cloud base, just about the time of passing upwind of the cloud, fly right into the lift forming the cloud. If approaching the cloud from a crosswind direction (for instance, heading north with westerly winds), try to estimate the thermal location from others encountered that day. If only reduced sink is found, there may be lift nearby, so a short leg upwind or downwind may locate the thermal.

Of course, thermals drift with the wind on blue days as well, and similar techniques are required to locate thermals using airborne or ground-based markers. For instance, if heading toward a circling glider but at a

Figure 10-4. Photograph of cloud streets.

thousand feet lower, estimate how much the thermal is tilted in the wind and head for the most likely spot upwind of the circling glider. [Figure 10-5] When in need of a thermal, pilots might consider searching on a line upwind or downwind once abeam the circling glider. This may or may not work; if the thermal is a bubble rather than a column, the pilot may be below the bubble. It is easy to waste height while searching in sink near one spot, rather than leaving and searching for a new thermal. Remember that a house thermal will likely be downwind of its typical spot on a windy day. Only practice and experience enable glider pilots to consistently find good thermals.

As a note, cool stable air can also drift with the wind. Avoid areas downwind of known stable air, such as large lakes or large irrigated regions. On a day with Cu, stable areas can be indicated by a big blue hole in an otherwise Cu-filled sky. If the area is broad enough, a detour upwind of the stabilizing feature might be in order. [Figure 10-6]

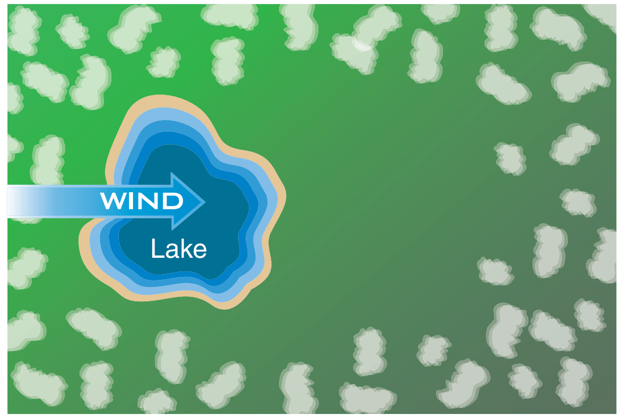

Figure 10-6. Blue hole in a field of cumulus downwind of a lake.

When the sky is full of Cu, occasional gliders are marking thermals, and dust devils move across the landscape, the sky becomes glider pilot heaven. If gliding in the upper part of the height band, it is best to focus on the Cu, and make choices based on the best clouds. Sometimes lower altitudes will cause glider pilots to go out of synch with the cloud. In that circumstance, use the Cu to find areas that appear generally active, but then start focusing more on ground-based indicators, like dust devils, a hillside with sunshine on it, or a circling bird. When down low, accept weaker climbs. Often the day cycles again, and hard work is rewarded.

When searching for lift, use the best speed to fly, that is, best L/D speed plus corrections for sink and any wind. This technique allows glider pilots to cover the most amount of ground with the available altitude.

Once a thermal has been located, enter it properly, so as not to lose it right away. The first indicator of a nearby thermal is often, oddly enough, increased sink. Next a positive G-force will be felt, which may be subtle or obvious depending on the thermal strength. The "seat-of-the-pants" indication of lift is the quickest, and is far faster than any variometer, which has a small lag. Speed should have been increased in the sink adjacent to the thermal, hence as the positive G-force increases, reduce speed to between L/D and minimum sink. Note the trend of the variometer needle (should be an upswing) or the audio variometer going from the drone to excited beeping, and at the right time in the anticipated lift, begin the turn. If everything has gone perfectly, the glider will roll into a coordinated turn, at just the right bank angle, at just the right speed, and be perfectly centered perfectly. In reality, it rarely works that well.

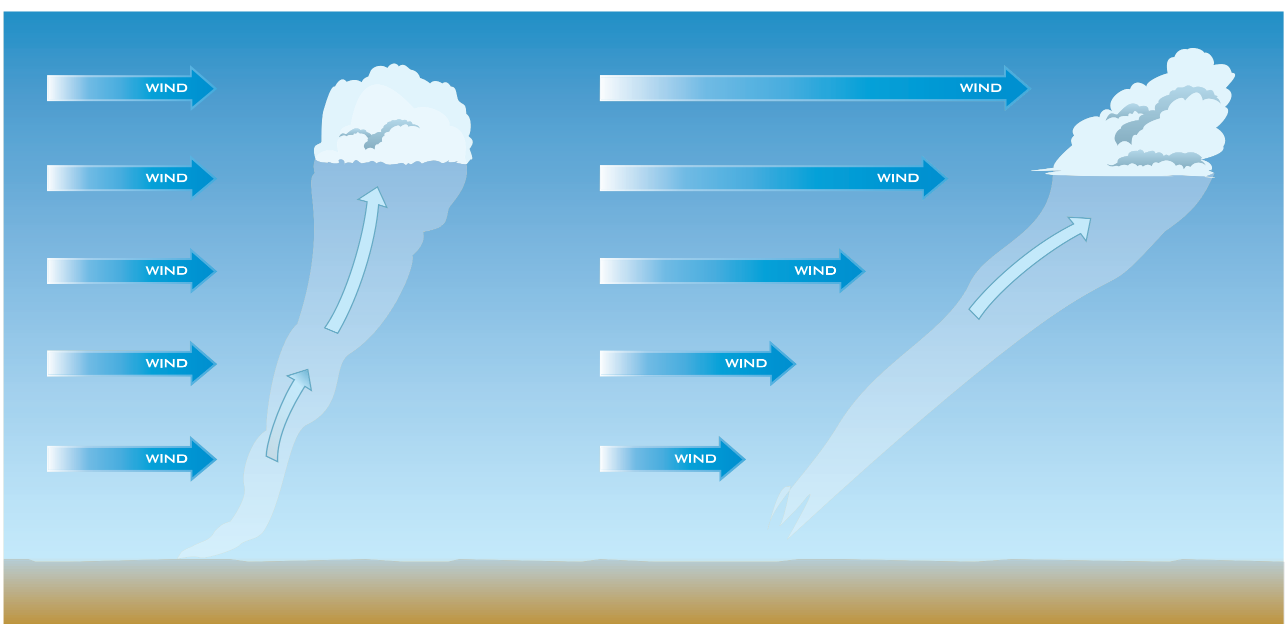

Figure 10-5. Thermal tilt in shear that (a) does not change with height, and that (b) increases with height.

Before going further, what vital step was left out of the above scenario? *CLEAR BEFORE TURNING!* The variometer is hypnotic upon entering lift, especially at somewhat low altitudes. This is exactly where pilots forget that basic primary step before any turn—looking around first. An audio variometer helps avoid this.

To help decide which way to turn, determine which wing is trying to be lifted. For instance, when entering the thermal and the glider is gently banking to the right, *CLEAR LEFT,* then turn left. A glider on its own tends to fly away from thermals. [Figure 10-7] As the glider flies into the first thermal, but slightly off center, the stronger lift in the center of the thermal banks the glider right, away from the thermal. It then encounters the next thermal with the right wing toward the center and is banked away from lift to the left, and so on. Avoid letting thermals bank the glider even slightly. Sometimes the thermal-induced bank is subtle, so be light on the controls and sensitive to the air activity. At other times there is no indication on one wing or another. In this case, take a guess, *CLEAR*, then turn. As a note, new soaring pilots often get in the habit of turning in a favorite direction, to the extreme of not being able to fly reasonable circles in the other direction. If this happens, make an effort to thermal in the other direction half the time—being proficient in either direction is important, especially when thermalling with traffic.

Optimum climb is achieved when proper bank angle and speed are used after entering a thermal. The shallowest possible bank angle at minimum sink speed is ideal. Thermal size and associated turbulence usually do not allow this. Large-size, smooth, and well-behaved thermals can be the exception in some parts of the country. Consider first the bank angle. The glider's sink rate increases as the bank angle increases. However, the sink rate begins to increase more rapidly beyond about a 45° bank angle. Thus, a 40° compared to a 30° bank angle may increase the sink rate less than the gain achieved from circling in the stronger lift near the center of the thermal. As with everything else, this takes practice, and the exact bank angle used will depend on the typical thermal, or even a specific thermal, on a given day. Normally bank angles in excess of 50° are not needed, but exceptions always exist. It may be necessary, for instance, to use banks of 60° or so to stay in the best lift. Thermals tend to be smaller at lower levels and expand in size as they rise higher. Therefore, a steeper bank angle is required at lower altitudes, and shallower bank angles can often be used while climbing higher. Remain flexible with techniques throughout the flight.

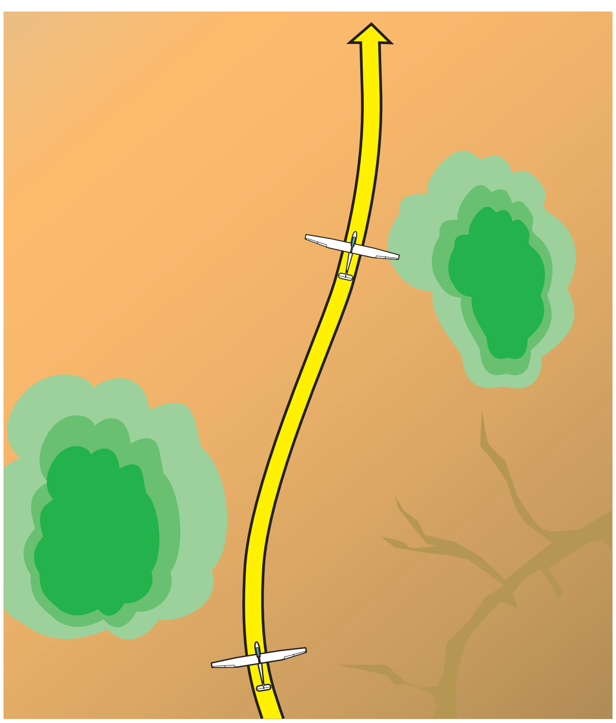

Figure 10-7. Effect of glider being allowed to bank on its own when encountering thermals.

If turbulence is light and the thermal is well-formed, use the minimum sink speed for the given bank angle. This should optimize the climb because the glider's sink rate is at its lowest, and the turn radius is smaller. As an example, for a 30° bank angle, letting the speed increase from 45 to 50 knots increases the diameter of the circle by about 100 feet. In some instances, this can make the difference between climbing or not. Some gliders can be safely flown several knots below minimum sink speed. Even though the turn radius is smaller, the increased sink rate may offset any gain achieved by being closer to strong lift near the thermal center.

There are two other reasons to avoid thermalling speeds that are too slow: the risk of a stall and lack of controllability. Distractions while thermalling can increase the risk of an inadvertent stall and include, but are not limited to: studying the cloud above or the ground below (for wind drift, etc.), quickly changing bank angles without remaining coordinated while centering, thermal turbulence, or other gliders in the thermal. Stall recovery should be second nature, so that if the signs of an imminent stall appear while thermalling, recovery is instinctive. Depending on the stall characteristics of the particular glider or in turbulent thermals, a spin entry is always possible. Glider pilots should carefully monitor speed and nose attitude at lower altitudes. Regardless of altitude, when in a thermal with other gliders below, maintain increased awareness of speed control and avoid any stall/spin scenario. Controllability is a second, though related, reason for using a thermalling speed greater than minimum sink. The bank angle may justify a slow speed, but turbulence in the thermal may make it difficult or impossible to maintain the desired quick responsiveness, especially in aileron control, in order to properly remain in the best lift. Using sufficient speed will ensure that the pilot, and not the thermal turbulence, is controlling the glider.

Soaring pilots' opinions differ regarding how long to wait after encountering lift and before rolling into the thermal. Some pilots advocate flying straight until the lift has peaked. Then, they start turning, hopefully back into stronger lift. It is imperative not to wait too long after the first indication that the thermal is decreasing for this maneuver. Other pilots favor rolling into the thermal before lift peaks, thus avoiding the possibility of losing the thermal by waiting too long. Turning into the lift too quickly will cause the glider to fly back out into sink. There is no one right way; the choice depends on personal preference and the conditions on a given day. Timing is everything and practice is key.

Usually upon entering a thermal, the glider is in lift for part of the circle and sink for the other part. It is rare to roll into a thermal and immediately be perfectly centered. The goal of centering the thermal is to determine where the best lift is and move the glider into it for the most consistent climb. One centering technique is known as the "270° correction." [Figure 10-8] In this case, the pilot rolls into a thermal and almost immediately encounters sink, an indication of turning the wrong way. Complete a 270° turn, straighten out for a few seconds, and if lift is encountered again, turn back into it in the same direction. Avoid reversing the direction of turn. The distance flown while reversing turns is more than seems possible and can lead away from the lift completely. [Figure 10-9]

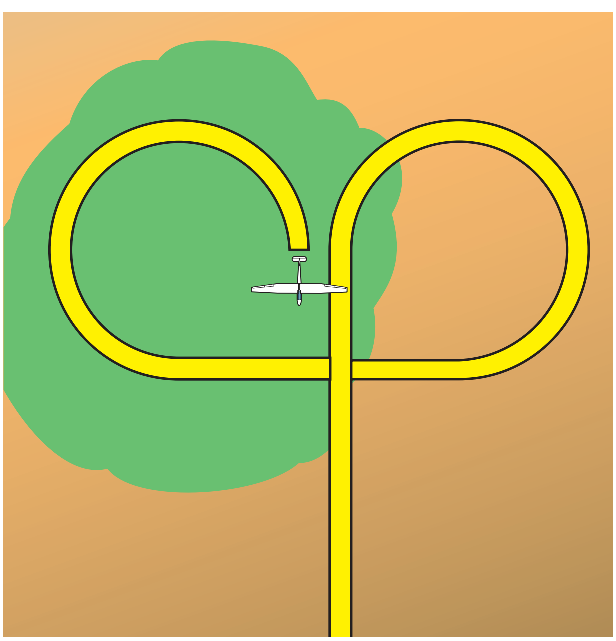

Figure 10-8. The 270° centering correction.

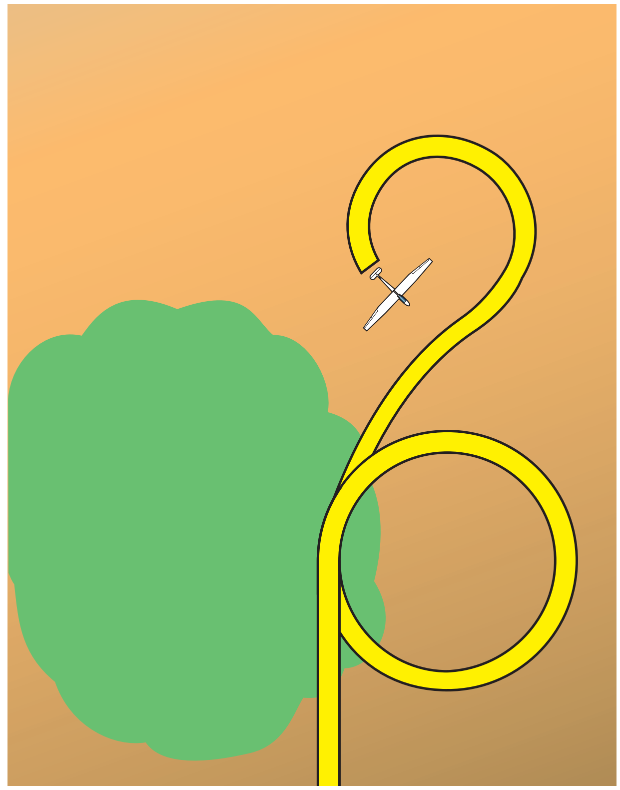

Figure 10-9. Possible loss of thermal while trying to reverse directions of circle.

Often stronger lift exists on one side of the thermal than on the other, or perhaps the thermal is small enough that lift exists on one side and sink on the other, thereby preventing a climb. There are several techniques and variations to centering. One method involves paying close attention to where the thermal is strongest, for instance, toward the northeast or toward some feature on the ground. To help judge this, note what is under the high wing when in the best lift. On the next turn, adjust the circle by either straightening or shallowing the turn toward the stronger lift. Anticipate things a bit and begin rolling out about 30° before actually heading towards the strongest part. This allows rolling back toward the strongest part of the thermal rather than flying through the strongest lift and again turning away from the thermal center. Gusts within the thermal can cause airspeed indicator variations; therefore, avoid "chasing the ASI." Paying attention to the nose attitude helps pilots keep their focus outside the cockpit. How long a glider remains shallow or straight depends on the size of the thermal. [Figure 10-10]

Other variations include the following. [Figure 10-11]

1. Shallow the turn slightly (by maybe 5° or 10°) when encountering the weaker lift, then as stronger lift is encountered again (feel the positive g, variometer swings up, audio variometer starts to beep) resume the original bank angle. If shallowing the turn too much, it is possible to fly completely away from the lift.

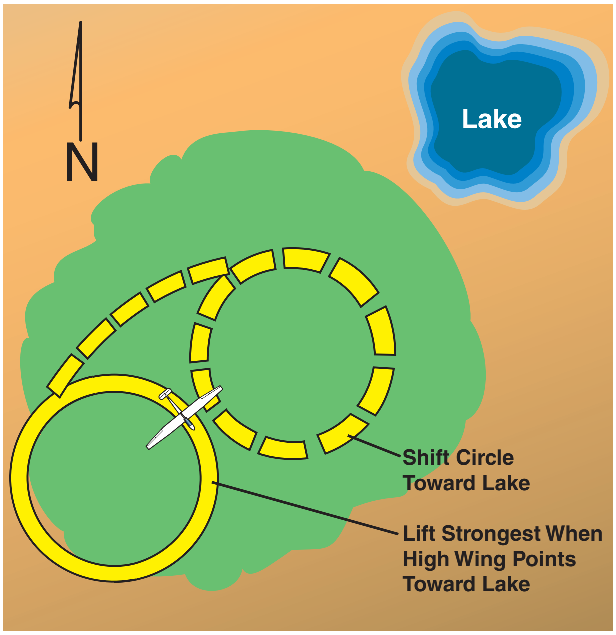

Figure 10-10. Centering by shifting the circle turn toward stronger lift.

2. Straighten or shallow the turn for a few seconds 60° after encountering the weakest lifts or worst sink indicated by the variometer. This allows for the lag in the variometer since the actual worst sink occurred a couple of seconds earlier than indicated. Resume the original bank angle.
3. Straighten or shallow the turn for a few seconds when the stronger seat-of-the-pants surge is felt. Then resume the original bank. Verify with the variometer trend (needle or audio).

For the new glider pilots, it is best to become proficient using one of the above methods first, and then experiment with other methods. As an additional note, thermals often deviate markedly from the conceptual model of concentric gradients of lift increasing evenly toward the center. For instance, it sometimes feels as if two (or more) nearby thermal centers exist, making centering difficult. Glider pilots must be willing to constantly adjust, and re-center the thermal to maintain the best climb.

In addition to helping pilots locate lift, other gliders can help pilots center a thermal as well. If a nearby glider seems to be climbing better, adjust the turn to fly within the same circle. Similarly, if a bird is soaring close by, it is usually worth turning toward the soaring bird. Along with the thrill of soaring with a hawk or eagle, it usually leads to a better climb.

Collision avoidance is of primary importance when thermalling with other gliders. The first rule calls for all gliders in a particular thermal to circle in the same direction. The first glider in a thermal establishes the direction of turn and all other gliders joining the thermal should turn in the same direction. Ideally, two gliders in a thermal at the same height or nearly so should position themselves across from each other so they can best maintain visual contact. [Figure 10-12] When entering a thermal, strive to do so in a way that will not interfere with gliders already in the thermal, and above all, in a manner that will not cause a hazard to other gliders. An example, of a dangerous entry, is pulling up to bleed off excess speed in the middle of a crowded thermal. A far safer technique is to bleed off speed before reaching the thermal and joining the thermal at a "normal" thermalling speed. Collision avoidance, not optimum aerodynamic efficiency, is the priority when thermalling with other gliders. Announcing to the other

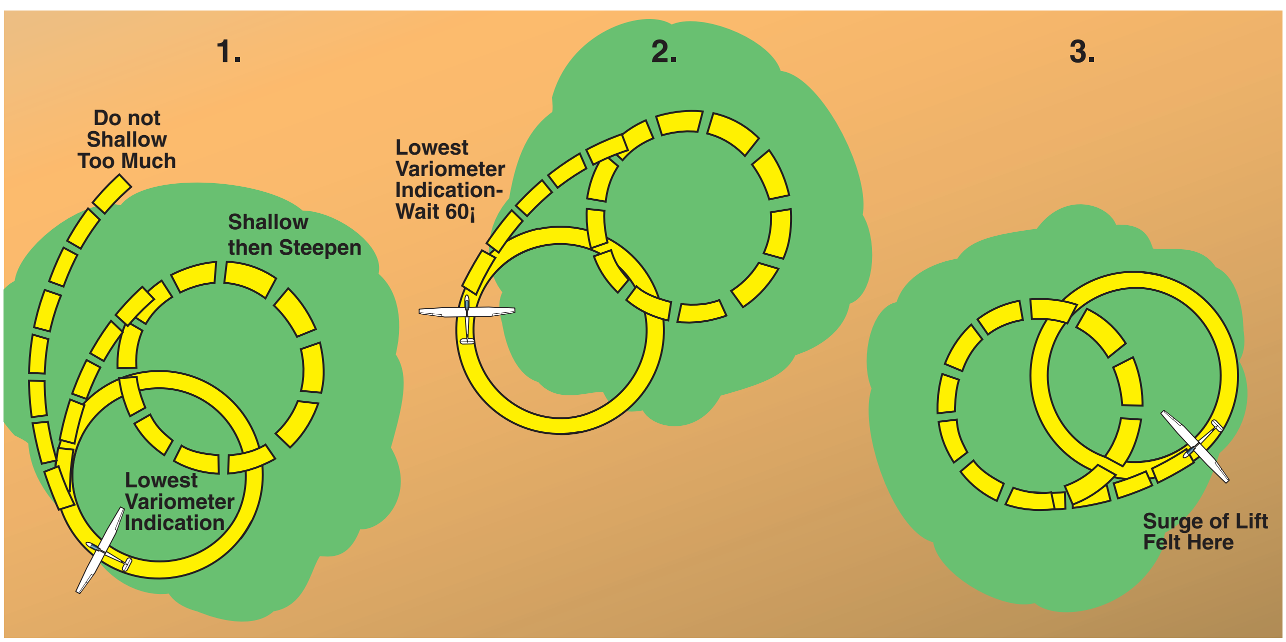

Figure 10-11. Other centering corrections.

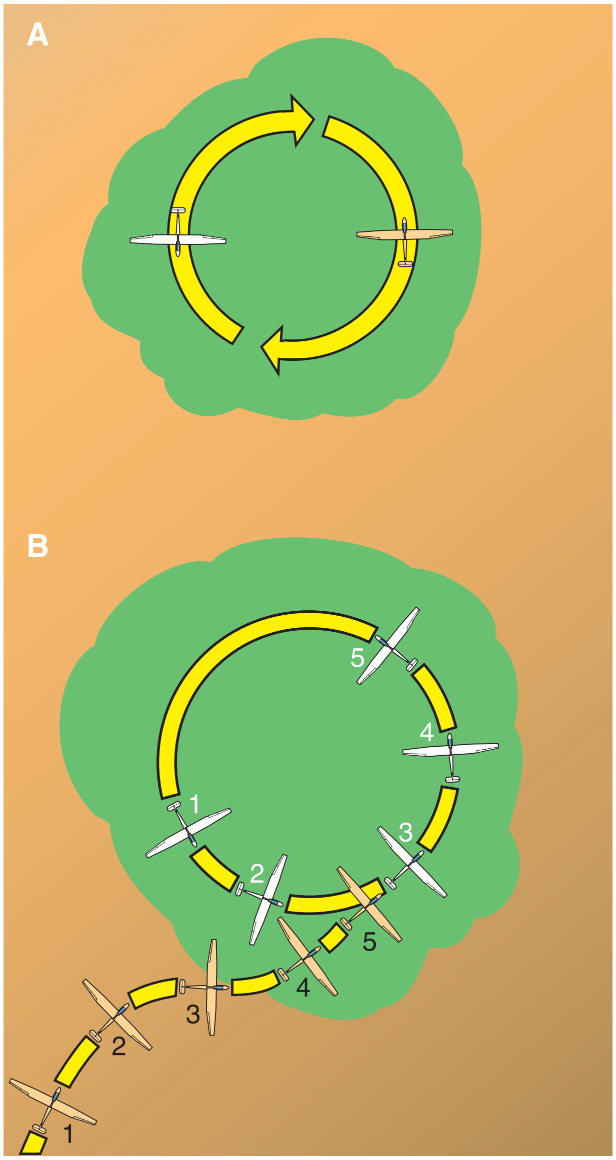

Figure 10-12. Proper positioning with two gliders at the same altitude. Numbers represent each glider's position at that time.

glider(s) on the radio when entering the thermal enhances collision avoidance. [Figure 10-12]

Different types of gliders in the same thermal may have different minimum sink speeds, and it may be difficult to remain directly across from another glider in a thermal. Avoid putting yourself in a situation where you cannot see the other glider, or the other glider cannot see you. Radio communication is helpful. Too much talking clogs the frequency, and may make it impossible for a pilot to broadcast an important message. Do not fly directly above or below another glider in a thermal since differences in performance, or even minor changes in speed can lead to larger than expected altitude changes. If you lose sight of another glider in a thermal and cannot establish position via a radio call, leave the thermal. After 10 or 20 seconds, come back around to rejoin the thermal, hopefully with better traffic positioning. It cannot be stressed enough that collision avoidance when thermalling is a priority! Mid-air collisions can sometimes be survived but only with a great deal of luck. Unsafe thermalling practices not only endangers your own safety but that of your fellow glider pilots. [Figure 10-13]

Leaving a thermal properly can also save you some altitude. While circling, scan the full 360° of sky with each thermalling turn. This first allows the pilot to continually check for other traffic in the vicinity. Second, it helps the pilot analyze the sky in all directions in order to decide where to go for the next climb. It is better to decide where to go next while still in lift rather than losing altitude in sink after leaving a thermal. Exactly when to leave depends on the goals for the climb—whether the desire is to maximize altitude for a long glide or leave when lift weakens in order to maximize time on a cross-country flight. In either case, be ready to increase speed to penetrate the sink often found on the edge of the thermal, and leave the thermal in a manner that will not hinder or endanger other gliders.

The preceding pages describe techniques for locating thermals, as well as entering, centering, and leaving thermals. Exceptions to normal or typical thermals are numerous. For instance, instead of stronger sink at the edge of a thermal, weak lift sometimes continues for a distance after leaving a thermal. Glider pilots should be quick to adapt to whatever the air has to offer at the

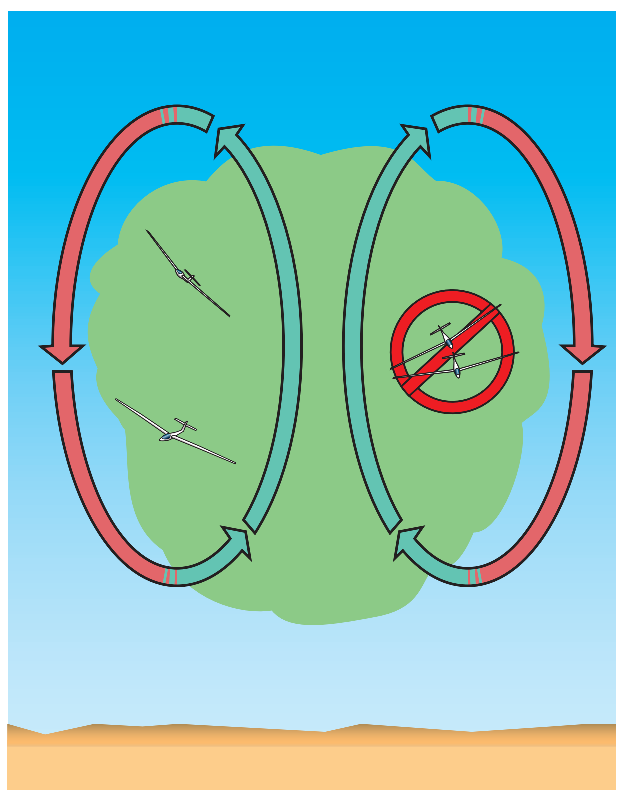

Figure 10-13. When thermalling, avoid flying in another glider's blind spot, or directly above or below another glider.

time. Just as the mechanics of simply flying the glider become second nature with practice, so do thermalling techniques. Expect to land early because anticipated lift was not there on occasion—it is part of the learning curve.

If **thermal waves** are suspected, climb in the thermal near cloud base, then head toward the upwind side of the Cu. Often, only very weak lift, barely enough to climb at all, is found in smooth air upwind of the cloud. Once above cloud base and upwind of the Cu, climb rates of a few hundred fpm can be found. Climbs can be made by flying back and forth upwind of an individual Cu, or by flying along cloud streets if they exist. If no clouds are present, but waves are suspected, climb to the top of the thermal and penetrate upwind in search of smooth, weak lift. Without visual clues, thermal waves are more difficult to work. Thermal waves are most often stumbled upon as a pleasant surprise when their presence is furthest from the pilot's mind.

RIDGE AND SLOPE SOARING

Efficient slope soaring (also called ridge soaring) is fairly easy; simply fly in the updraft along the upwind side of the ridge (see Figure 9-20). The horizontal distance from the ridge will vary with height above the ridge, since the best lift zone tilts upwind with height above the ridge. Even though the idea is simple, traps exist for both new and expert glider pilots. Obtain instruction when first learning to slope soar.

Avoid approaching from the upwind side perpendicularly to the ridge. Instead, approach the ridge at a shallower angle, so that a quick egress away from the ridge is possible should lift not be contacted. While flying along the ridge, a crab angle is necessary to avoid drifting too close to the ridge or, if gliding above the ridge, to avoid drifting over the top into the lee-side downdraft. For the new glider pilot, crabbing along the ridge may be a strange sensation, and it is easy to become uncoordinated while trying to point the nose along the ridge. This is both inefficient and dangerous, since it leads to a skid toward the ridge. [Figure 10-14]

In theory, to obtain the best climb, it is best to slope soar at minimum sink speed. However, flying that slowly may be unwise for two reasons. First, minimum sink speed is relatively close to stall speed, and flying close to stall speed near terrain has obvious dangers. Second, maneuverability at minimum sink speed may be inadequate for proper control near terrain, especially if the wind is gusty and/or thermals are present. When gliding at or below ridge top height, fly faster than minimum sink speed—how much faster depends on the glider, terrain, and turbulence. When the glider is at least several hundred feet above the ridge and shifting upwind away from it in the best lift zone, reduce speed. If in doubt, fly faster!

Slope soaring comes with several procedures to enable safe flying and to allow many gliders on the same ridge. The rules are:

1. make all turns away from the ridge;
2. do not fly directly above or below another glider;
3. pass another glider on the ridge side, anticipating that the other pilot will make a turn away from the ridge; and
4. the glider with its right side to the ridge has the right of way. [Figure 10-15]

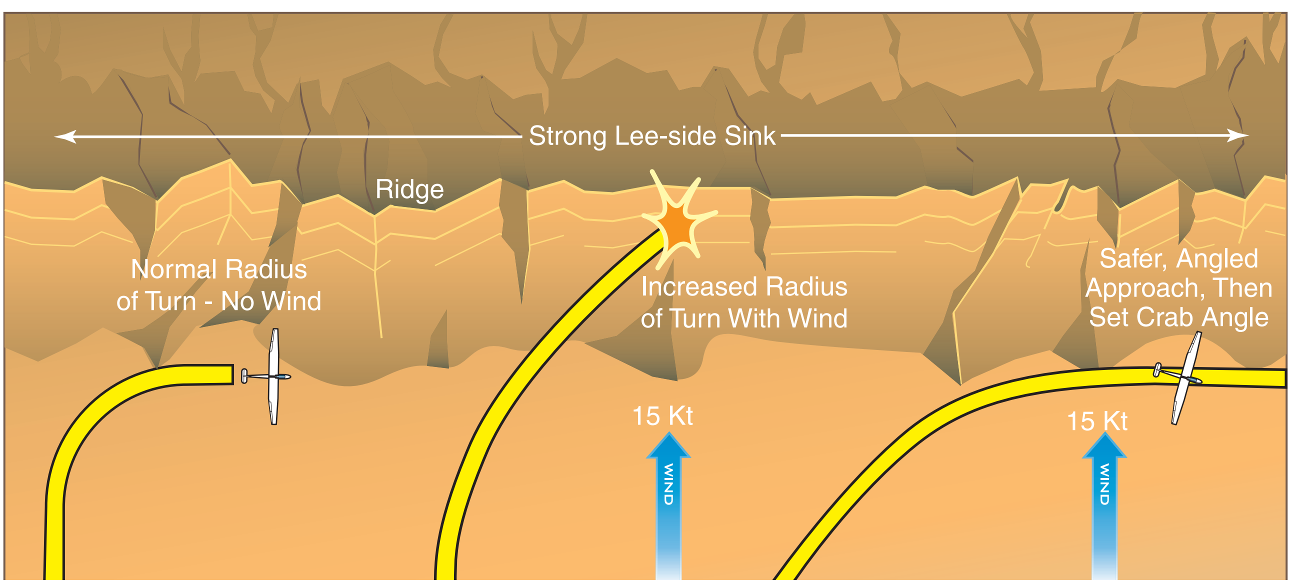

Figure 10-14. Flying with a wind increases the turn radius over the ground, so approach the ridge at a shallow angle.

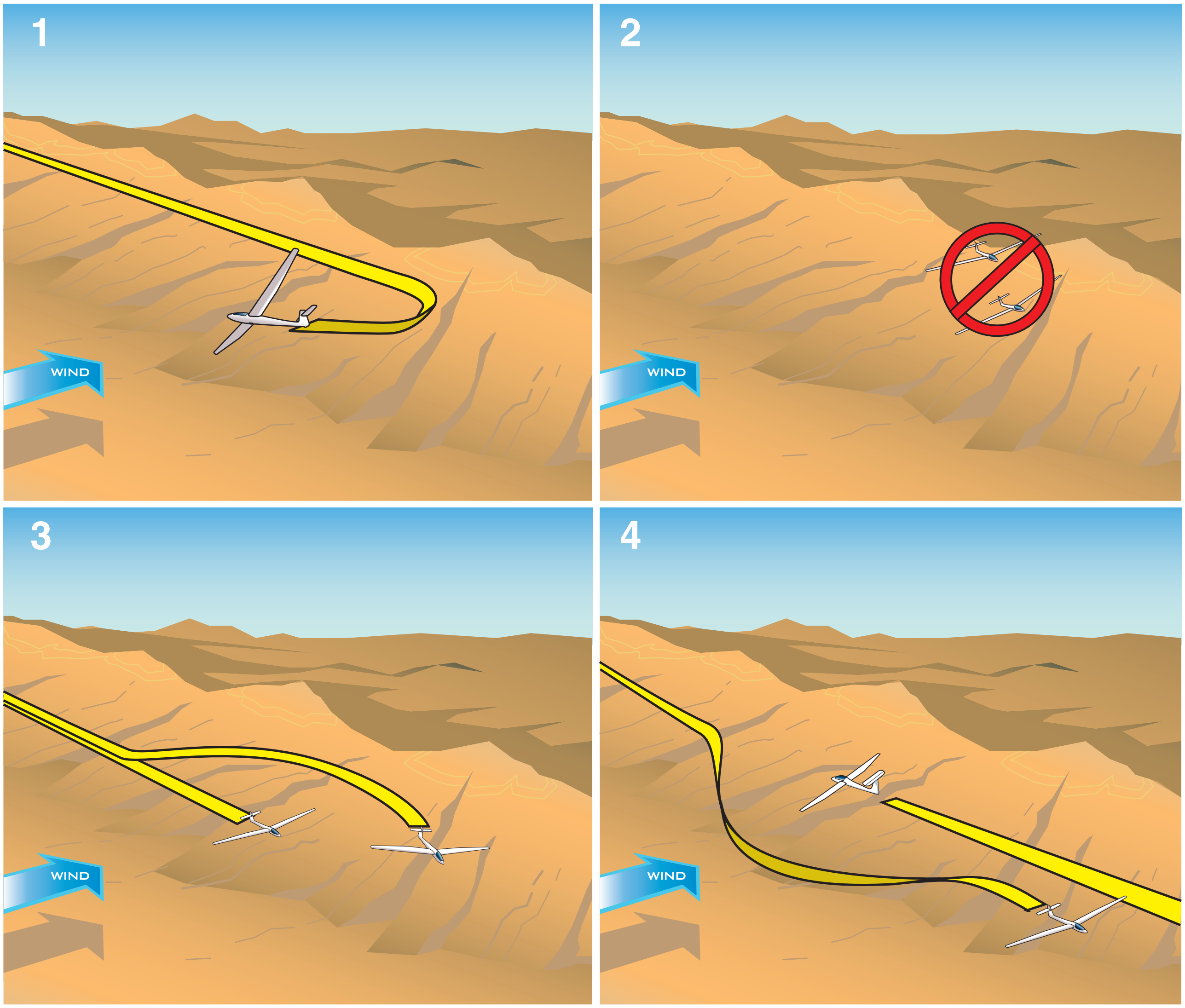

Figure 10-15. Ridge rules.

These procedures deserve some comment.

Procedure #1: A turn toward the ridge is dangerous, even if gliding seemingly well away from the ridge. The ground speed on the downwind portion of the turn will be difficult to judge properly, and striking the ridge is a serious threat. Even if above the ridge, it will be easy to finish the turn downwind of the ridge in heavy sink.

Procedure #2: Gliders spaced closely together in the vertical are in each other's blind spots. A slight change in climb-rate between the gliders can lead to a collision.

Procedure #3: Sometimes the glider to be passed is so close to the ridge that there is inadequate space to pass between the glider and the ridge. In that case, either turn back in the other direction (away from the ridge) if traffic permits, or fly upwind away from the ridge and rejoin the slope lift as traffic allows. When soaring outside of the United States, be aware that this rule may differ.

Procedure #4: Federal Aviation Regulations call for aircraft approaching head-on to both give way to the right. A glider with the ridge to the right may not have room to move in that direction. The glider with its left side to the ridge should give way. When piloting the glider with its right side to the ridge, make sure the approaching glider sees you and is giving way in plenty of time. In general, gliders approaching head-on are difficult to see; therefore, extra vigilance is needed to avoid collisions while slope soaring.

If the wind is at an angle to the ridge, bowls or spurs extending from the main ridge can create better lift on the upwind side and sink on the downwind side. If at or near the height of the ridge, it may be necessary to detour around the spur to avoid the sink, then drift back into the bowl to take advantage of the better lift. After passing such a spur, do not make abrupt turns toward the ridge (Rule #1), and as always, consider what the general flow of traffic is doing. If soaring hundreds of feet above a spur, it may be possible to fly over it and increase speed in any sink. This requires caution, since a thermal in the upwind bowl, or even an imperceptible increase in the wind, can cause greater than anticipated sink on the downwind side. Always have an escape route or, if in any doubt, detour around. [Figure 10-16]

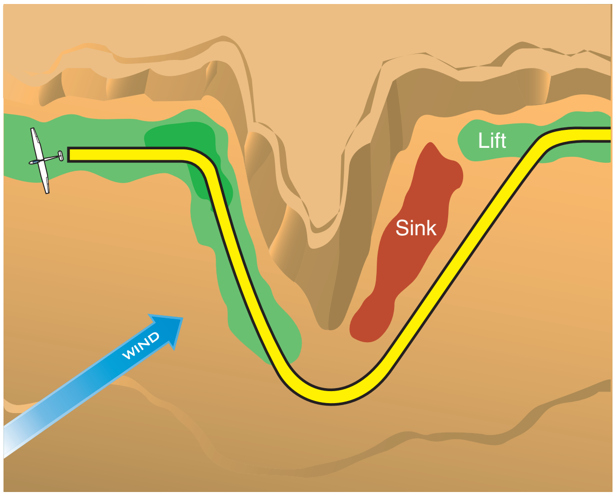

Figure 10-16. Avoid sink on the downwind side of spurs by detouring around them.

It is not uncommon for thermals to exist with slope lift. Indeed, slope soaring can often be used as a "save" when thermals have temporarily shut down. Working thermals from slope lift requires special techniques. When a thermal is encountered along the ridge, a series of S-turns can be made into the wind. Drift back to the thermal after each turn if needed and, of course, never continue the turn to the point that the glider is turning toward the ridge. Speed is also important, since it is easy to encounter strong sink on the sides of the thermal. It is very likely that staying in thermal lift through the entire S-turn is not possible. The maneuver takes practice, but when done properly, a rapid climb in the thermal can be made well above the ridge crest, where thermalling turns can begin. Even when well above the ridge, caution is needed to ensure the climb is not too slow as to drift into the lee-side sink. Before trying S-turns make sure it will not interfere with other traffic along the ridge. [Figure 10-17]

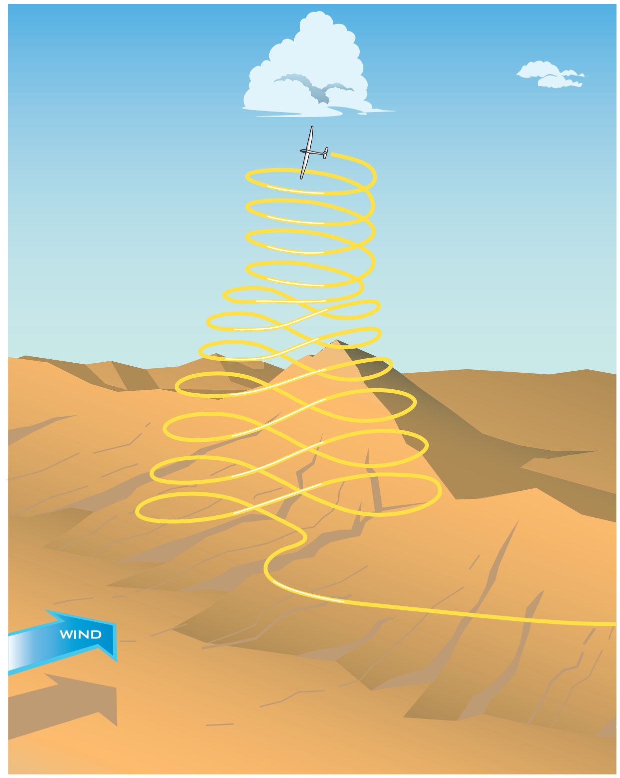

Figure 10-17. One technique for catching a thermal from ridge lift.

A second technique for catching thermals when slope soaring is to head upwind away from the ridge. This works best when Cu mark potential thermals and aide timing. If no thermal is found, the pilot should cut the search short while still high enough to dash back downwind to the safety of the slope lift. [Figure 10-18]

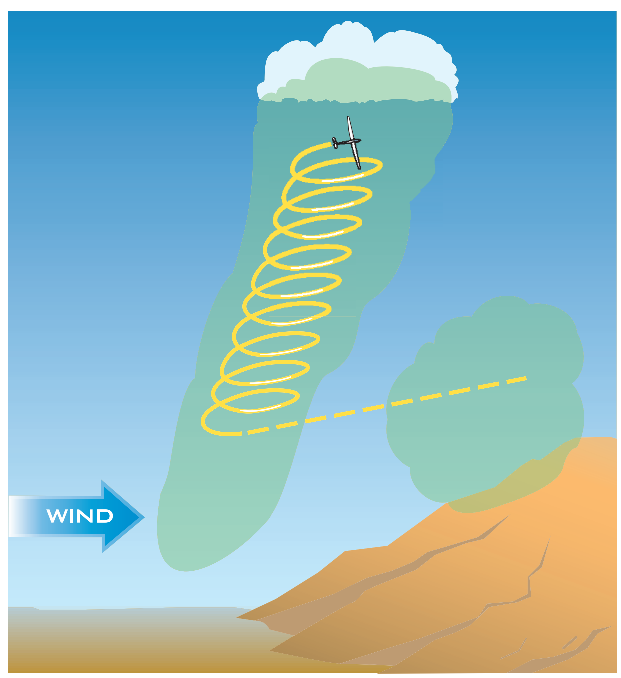

Figure 10-18. Catching a thermal by flying upwind away from the slope lift.

As a final note, caution is also needed to avoid obstructions when slope soaring. These primarily include wires, cables, and power lines, all of which are very difficult to see. Aeronautical charts show high-tension towers that, of course, have many wires between them. Soaring pilots familiar with the area should be able to provide useful information on any problems with the local ridge.

WAVE SOARING

Almost all high-altitude flights are made using mountain lee waves. As covered in Chapter 9—Soaring Weather, lee wave systems can contain tremendous turbulence in the rotor, while the wave flow itself is usually unbelievably smooth. In more recent years, the use of lee waves for cross-country soaring has lead to flights exceeding 1,500 miles, with average speeds over 100 mph. [Figure 10-19]

PREFLIGHT PREPARATION

The amount of preflight preparation depends on the height potential of the wave itself. Let us assume that the pilot is planning a flight above 18,000 feet MSL during the winter. (Pilots planning wave flights to much lower altitudes can reduce the list of preparation items accordingly.)

For flights above 14,000 feet MSL, the CFRs state that required crewmembers must use supplemental oxygen. Pilots must be aware of their own physiology; however, it may be wise to use oxygen at altitudes well below 14,000 feet MSL. In addition, signs of hypoxia should be known. The U.S. Air Force in cooperation with the FAA provides a one-day, high-altitude orientation and chamber ride for civilian pilots. The experience is invaluable for any pilot contemplating high altitude soaring and is even required by many clubs and operations as a prerequisite. Before any wave flight, it is important to be thoroughly familiar with the specific oxygen system that will be used, as well as its adequacy for potential heights. The dangers of oxygen deprivation should not be taken lightly. At around 20,000 feet MSL pilots might have only 10 minutes of "useful consciousness." By 30,000 feet MSL, the timeframe for "useful consciousness" decreases to one minute or less! For planned flights above 25,000 feet MSL, an emergency oxygen back-up or **bailout bottle** should be carried.

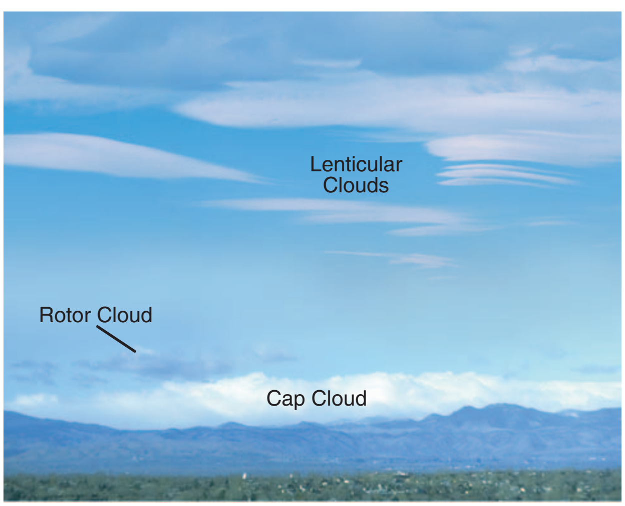

Figure 10-19. Rotor and cap clouds with lenticulars above.

Proper clothing is a must since temperatures of –30° to –60°C may be encountered at altitude. Proper preparation for the cold is especially difficult since temperatures on the ground are often pleasant on wave soaring days. Sunshine through the canopy keeps the upper body amazingly warm for a time, but shaded legs and feet quickly become cold. Frostbite is a very real threat. After an hour or two at such temperatures, even the upper body can become quite cold. Layered, loose -fitting clothing aides in insulating body heat. Either wool gloves or light fitting gloves with mittens over them work best for the hands. Mittens make tasks such as turning radio knobs difficult. For the feet, two or three pair of socks (inner silk, outer wool) with an insulated boot is recommended.

Within the continental United States, Class A airspace lies between 18,000 and 60,000 feet MSL (FL 180 to FL 600). Generally, flights in Class A must be conducted under Instrument Flight Rules (IFR). However, several clubs and glider operations have established so-called **"Wave Windows"**. These are special areas, arranged in agreement with Air Traffic Control (ATC), in which gliders are allowed to operate above 18,000 feet MSL under VFR operations. Wave windows have very specific boundaries. Thus, to maintain this privilege, it is imperative to stay within the designated window. On any given day, the wave window may be opened to a specific altitude during times specified by ATC. Each wave window has its own set of procedures agreed upon with ATC. All glider pilots should become familiar with the procedures and required radio frequencies.

True Airspeed (TAS) becomes a consideration at higher altitudes. To avoid the possibility of flutter, some gliders require a reduced indicated never-exceed speed as a function of altitude. For instance, at sea level the POH for one common two-seat glider, the V_{NE}, is 135 knots. However, at 19,000 feet MSL it is only 109 knots. Study the glider's POH carefully for any limitations on indicated airspeeds.

There is always the possibility of not contacting the wave. Sink on the downside of a lee wave can be high—2,000 fpm or more. In addition, missing the wave often means a trip back through the turbulent rotor. The workload and stress levels in either case can be high. To reduce the workload, it is a good idea to have minimum return altitudes from several locations calculated ahead of time. In addition, plan for some worse case scenarios. For instance, consider what off-field landing options are available if the planned minimum return altitude proves inadequate.

A normal preflight of the glider should be performed. In addition, check the lubricant that has been used on control fittings. Some lubricants can become very stiff when cold. Also, check for water from melting snow or a recent rain in the spoilers or dive brakes. Freezing water in the spoilers or drive brakes at altitude can make them difficult to open. Checking the spoilers or dive brakes occasionally during a high climb helps avoid this problem. A freshly charged battery is recommended, since cold temperatures can reduce battery effectiveness. Check the radio and accessory equipment, such as a microphone in the oxygen mask even if it is not generally used. As mentioned, the oxygen system is vital. Other specific items to check depend on the system being used. A checklist such as PRICE is often helpful. The acronym PRICE stands for:

- Pressure—Check pressure in the oxygen bottle.
- Regulator—Check at all settings.
- Indicator—Check flow meters or flow-indicator blinkers.
- Connections—Check for solid connections, possible leaks, cracks in hoses, etc.
- Emergency—Check that the system is full and properly connected.

A briefing with the towpilot is even more important before a wave tow. Routes, minimum altitudes, rotor avoidance (if possible), anticipated tow altitude, and eventualities should the rotor become too severe, are among topics that are best discussed on the ground prior to flight.

After all preparations are complete, it is time to get in the glider. Some pilots may be using a parachute for the first time on wave flights, so make sure you are familiar with its proper fitting and use. The parachute fits on top of clothing that is much bulkier than for normal soaring, so the cockpit can suddenly seem quite cramped. It will take several minutes to get settled and organized. Make sure radio and oxygen are easily accessible. If possible, the oxygen mask should be in place, since the climb in the wave can be very rapid. At the very least, the mask should be set up so that it is ready for use in a few seconds. All other gear (e.g., mittens, microphone, maps, barograph, etc.) should be securely stowed in anticipation of the rotor. Check for full, free rudder movement, since footwear is likely larger than what you normally use. In addition, given the bulky cold-weather clothing, check to make sure the canopy clearance is adequate. The pilot's head has broken canopies in rotor turbulence so seat and shoulder belts should be tightly secured. This may be difficult to achieve with the extra clothing and accessories, but take the time to make sure everything is secure. There will not be time to attend to such matters once the rotor is encountered.

GETTING INTO THE WAVE

There are two possibilities for getting into the wave: soaring into it or being towed directly into it. Three main wave entries while soaring are: thermalling into the wave, climbing the rotor, and transitioning into the wave from slope soaring.

At times, an unstable layer at levels below the mountaintop is capped by a strong, stable layer. If other conditions are favorable, the overlying stable layer may support lee waves. On these days, it is sometimes possible to largely avoid the rotor and thermal into the wave. Whether lee waves are suspected or not, near the thermal top the air may become turbulent. At this point, attempt a penetration upwind into smooth wave lift. A line of cumulus downwind of and aligned parallel to the ridge or mountain range is a clue that waves may be present. [Figure 10-20]

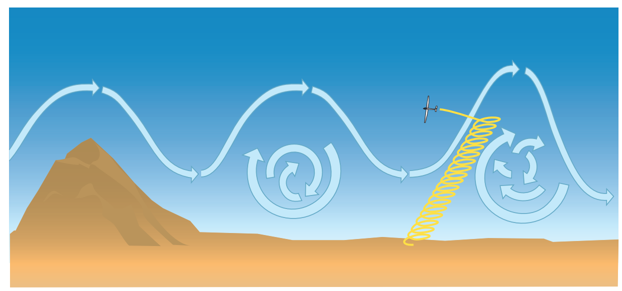

Figure 10-20. Thermalling into wave.

Another possibility is to tow into the upside of the rotor, then climb the rotor into the wave. This can be rough, difficult, and prone to failure. The technique is to find a part of the rotor that is going up and try to stay in it. The rotor lift is usually stationary over the ground. Either "figure-8" in the rotor lift to avoid drifting downwind, fly several circles with an occasional straight leg, or fly straight into the wind for several seconds until lift diminishes. Then circle to reposition in the lift. Which choice works depends on the size of the lift and the wind strength. Since rotors have rapidly changing regions of very turbulent lift and sink, simple airspeed and bank angle control can become difficult. This wave-entry technique is not for new pilots.

Depending on the topography near the soaring site, it may be possible to transition from slope lift into a lee wave that is created by upwind topography as shown in Figure 9-27. In this case, climb as high as possible in slope lift, then penetrate upwind into the lee wave. When the lee waves are in phase with the topography, it is often possible to climb from slope to wave lift without the rotor. At times, the glider pilot may not realize wave has been encountered until they find lift steadily increasing as they climb from the ridge. Climbing in slope lift and then turning downwind to encounter possible lee waves produced downwind of the ridge is generally not recommended. Even with a tailwind, the lee-side sink can put the glider on the ground before the wave is contacted.

Towing into the wave can be accomplished by either towing ahead of the rotor or through the rotor. Avoiding the rotor completely will generally increase the towpilot's willingness to perform future wave tows. If possible, tow around the rotor and then directly into the wave lift. This may be feasible if the soaring site is located near one end of the wave-producing ridge or mountain range. A detour around the rotor may require more time on tow, but it's well worth the diversion. [Figure 10-21]

Often, a detour around the rotor is not possible and a tow directly through the rotor is the only route to the wave. The rotor turbulence is, on rare occasion, only light. However, moderate to severe turbulence is usually encountered. The nature of rotor turbulence differs from turbulent thermal days, with sharp, chaotic horizontal and vertical gusts along with rapid accelerations and decelerations. At times, the rotor can become so rough that even experienced pilots may elect to remain on the ground. Any pilot inexperienced in flying through rotors should obtain instruction before attempting a tow through rotor.

When towing through a rotor, being out of position is normal. Glider pilots must maintain position horizontally and vertical as best they can. Pilots should also be aware that an immediate release may be necessary at any time if turbulence becomes too violent. Slack-producing situations are common, due to a rapid deceleration of the towplane. The glider pilot must react quickly to slack if it occurs and recognize that slack is about to occur and correct accordingly. The vertical position should be the normal high-tow. Any tow position that is lower than normal runs the risk of the slack line coming back over the glider. On the other hand, care should be taken to tow absolutely no higher than normal to avoid a forced release should the towplane suddenly drop. Gusts may also cause an excessive bank of the glider, and it may take a moment to roll back to level. Full aileron and rudder deflection, held for a few seconds, is sometimes needed.

Progress through the rotor is often indicated by noting the trend of the variometer. General down swings are replaced by general upswings, usually along with increasing turbulence. The penetration into the smooth wave lift can be quick, in a matter of few seconds, while at other times it can be more gradual. Note any lenticulars above—a position upwind of the clouds helps confirm contact with the wave. If in doubt, tow a few moments longer to be sure. Once confident about having contacted the wave lift, make the release. If heading more or less crosswind, the glider should release and fly straight or with a crab angle. If flying directly into the wind, the glider should turn a few

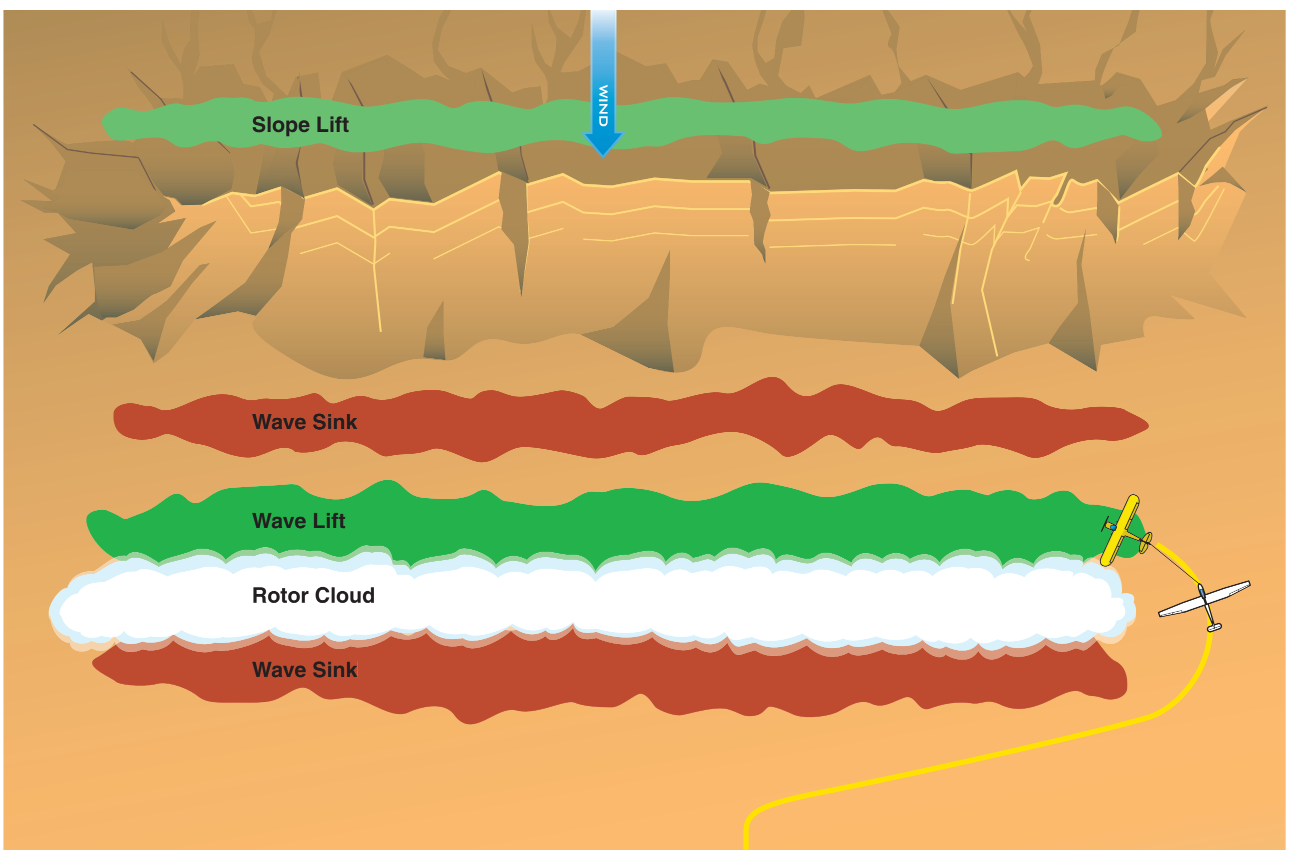

Figure 10-21. If possible, tow around the rotor directly into the wave.

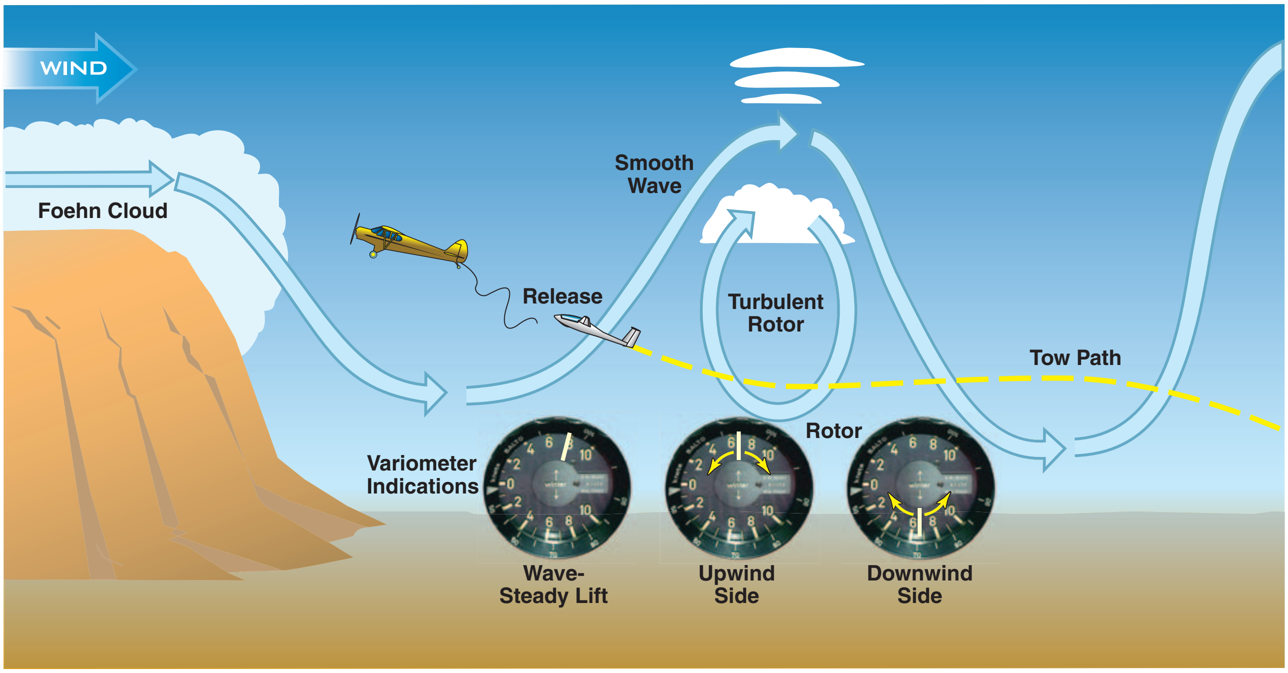

Figure 10-22. Variometer indications during the penetration into the wave.

degrees to establish a crosswind crab angle. The goal is to avoid drifting downwind and immediately lose the wave. After release, the towplane should descend and/or turn away to separate from the glider. Possible non-standard procedures need to be briefed with the towpilot before takeoff. [Figures 10-22 and 10-23]

FLYING IN THE WAVE

Once the wave has been contacted, the best techniques for utilizing the lift depends on the extent of the lift (especially in the direction along the ridge or mountain range producing the wave) and the strength of the wind. The lift may initially be weak. In such circumstances, be patient and stay with the initial slow climb. Patience is usually rewarded with better lift as the climb continues. At other times, the variometer may be pegged at 1,000 fpm directly after release from tow.

If the wind is strong enough (40 knots or more), find the strongest portion of the wave and point into the wind, and adjust speed so that the glider remains in the strong lift. The best lift will be found along the upwind side of the rotor cloud or just upwind of any lenticulars. In the best-case scenario, the required speed will be close to the glider's minimum sink speed. In quite strong winds, it may be necessary to fly faster than minimum sink to maintain position in the best lift. Under those conditions, flying slower will allow the glider to drift downwind (fly backwards over the ground!) and into the down side of the wave. This can be a costly mistake since it will be difficult to penetrate

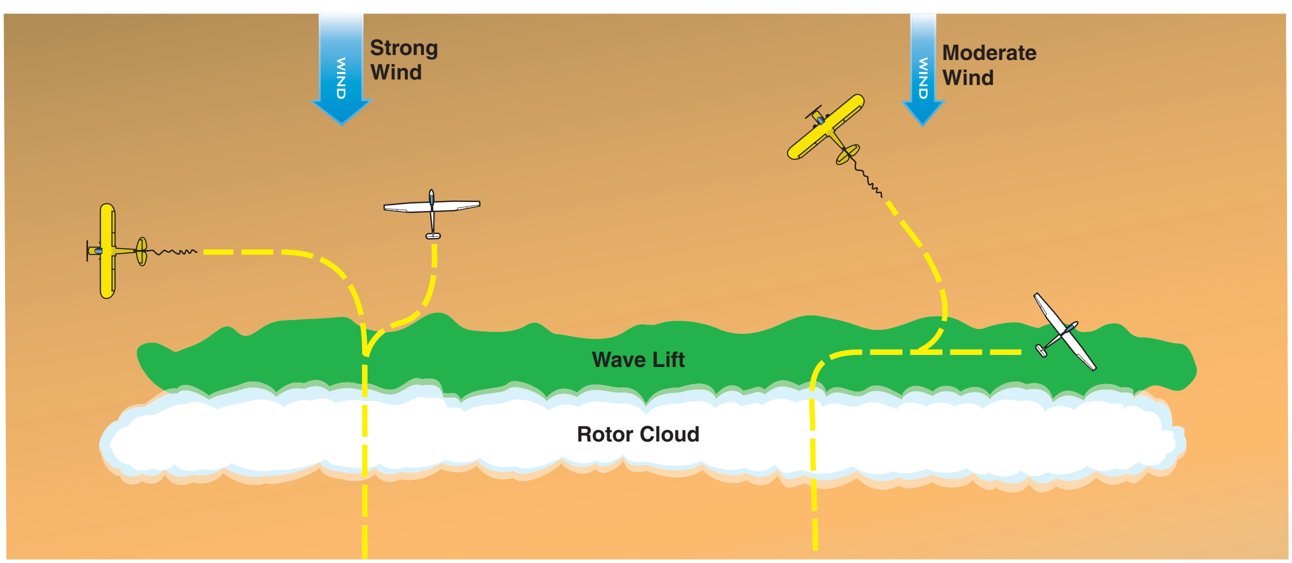

Figure 10-23. Possible release and separation on a wave tow.

back into the strong headwind. When the lift is strong, it is easy to drift downwind while climbing into stronger winds aloft, so it pays to be attentive to the position relative to rotor clouds or lenticulars. If no clouds exist, special attention is needed to judge wind drift by finding nearby ground references. It may be necessary to increase speed with altitude to maintain position in the best lift. Often the wind is strong, but not quite strong enough for the glider to remain stationary over the ground, so that the glider slowly moves upwind out of the best lift. If this occurs, turn slightly from a direct upwind heading, drift slowly downwind into better lift, and turn back into the wind before drifting too far. [Figure 10-24]

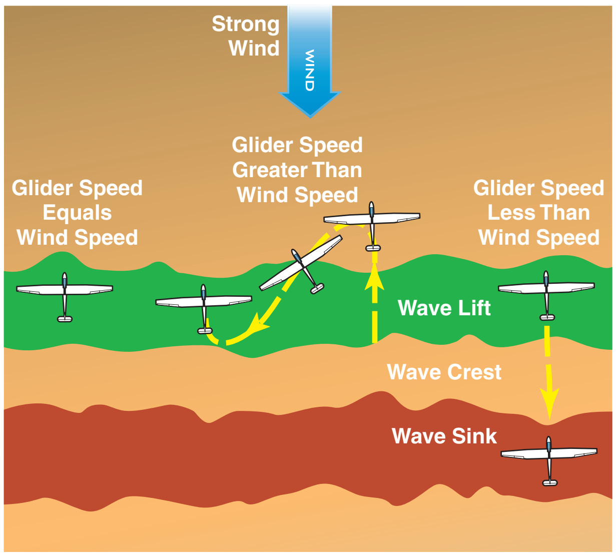

Figure 10-24. Catching a thermal by flying upwind away from the slope lift.

Oftentimes, the wave lift is not perfectly stationary over the ground since small changes in wind speed and/or stability can alter the wavelength of the lee wave within minutes. If lift begins to decrease while climbing in the wave, one of these things has occurred: the glider is nearing the top of the wave, the glider has moved out of the best lift, or the wavelength of the lee wave has changed. In any case, it is time to explore the area for better lift, and it is best to search upwind first. Searching upwind first allows the pilot to drift downwind back into the up part of the wave if he or she is wrong. Searching downwind first can make it difficult or impossible to contact the lift again if sink on the downside of the wave is encountered. In addition, caution is needed to avoid exceeding the glider's maneuvering speed or rough-air redline, since a penetration from the down side of the wave may put the glider back in the rotor. [Figure 10-25]

If the winds are moderate (20 to 40 knots), and the wave extends along the ridge or mountain range for a few miles, it is best to fly back and forth along the wave

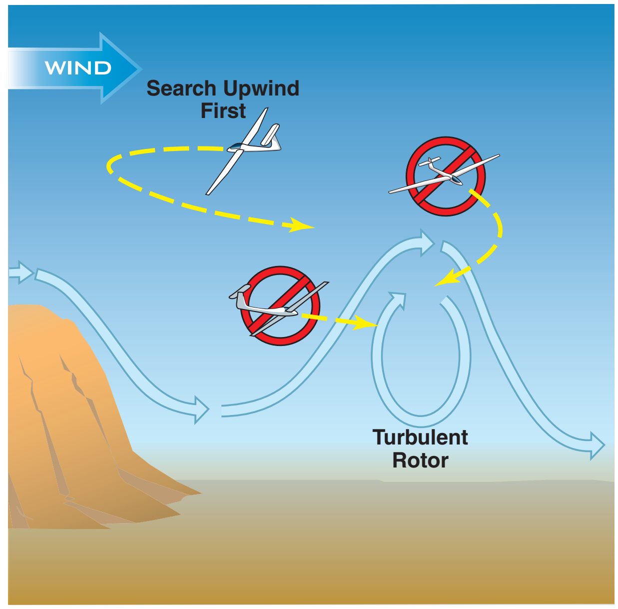

Figure 10-25. Search upwind first to avoid sink behind the wave crest or the rotor.

lift while crabbing into the wind. This technique is similar to slope soaring, using the rotor cloud or lenticular as a reference. All turns should be into the wind to avoid ending up on the down side of the wave or back into the rotor. Once again, it is easy to drift downwind into sink while climbing higher and searching for better lift should be done upwind first. When making an upwind turn to change course 180°, remember that the heading change will be less, depending on the strength of the wind. Note the crab angle needed to stay in lift on the first leg, and assume that same crab angle after completing the upwind turn. This will prevent the glider from drifting too far downwind upon completing the upwind turn. With no cloud, ground references are used to maintain the proper crab angle, and avoid drifting downwind out of the lift. While climbing higher into stronger winds, it may become possible to transition from crabbing back and forth to a stationary upwind heading. [Figure 10-26]

Weaker winds (15 to 20 knots) sometimes require different techniques. Lee waves from smaller ridges can form in relatively weak winds, on the order of only 15 knots. Wave lift from larger mountains will rapidly decrease when climbing to a height where winds aloft diminish. As long as the lift area is big enough, use a technique similar to that used in moderate winds. Near the wave top, there sometimes remains only a small area that still provides lift. In order to attain the maximum height; fly shorter "figure-8" patterns within the remaining lift. If the area of lift is so small that consistent climb is not possible, a series of circles can be flown with an occasional leg into the wind to avoid drifting too far downwind. Another possibility is an oval-shaped pattern—fly straight into the wind in lift, and as it diminishes, fly a quick 360° turn to reposi-

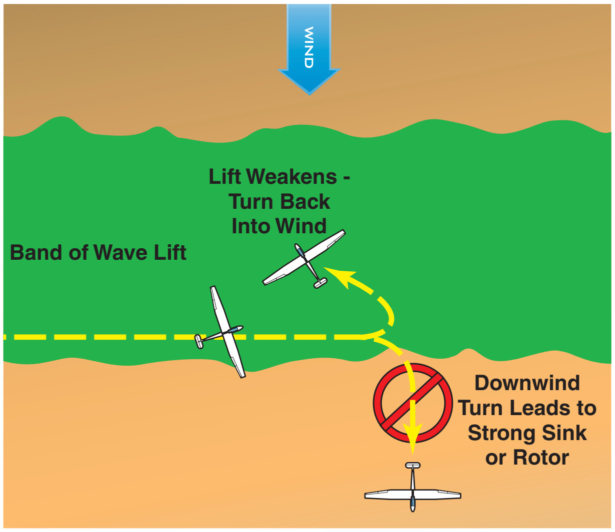

Figure 10-26. Proper crabbing to stay in lift and effects of upwind turn (correct) or downwind turn (incorrect).

tion. These last two techniques do not work as well in moderate winds, and not at all in strong winds since it is too easy to end up downwind of the lift and into heavy sink. [Figure 10-27]

In the discussion thus far, we have assumed a climb in the primary wave. It is also possible to climb in the secondary or tertiary lee wave (if they exist on a given day) and then penetrate into the next wave upwind. The success of this depends on wind strength, clouds, the intensity of sink downwind of wave crests, and the performance of the glider. Depending on the height attained in the secondary or tertiary lee wave, a trip through the rotor of the next wave upwind is a distinct possibility. Caution is needed if penetrating upwind at high speed. The transition into the downwind side of the rotor can be as abrupt as on the upwind side, so speed should be reduced at the first hint of turbulence. In any case, expect to lose surprising amounts of altitude while penetrating upwind through the sinking side of the next upwind wave. [Figure 10-28]

If a quick descent is needed or desired, the sink downwind of the wave crest can be used. Sink can easily be twice as strong as lift encountered upwind of the crest. Eventual descent into downwind rotor is also likely. Sometimes the space between a rotor cloud and overlying lenticulars is inadequate and a transition downwind cannot be accomplished safely. In this case, a crosswind detour may be possible if the wave is produced by a relatively short ridge or mountain range. If clouds negate a downwind or crosswind departure from the wave, a descent on the upwind side of the wave crest will be needed. Spoilers or dive brakes may be used to descend through the updraft, followed by a transition under the rotor cloud and through the rotor. A descent can be achieved by moving upwind of a very strong wave lift if spoilers or dive brakes alone do not allow a quick enough descent. A trip back through the rotor is at best unpleasant. At worst it can be dangerous if the transition back into the rotor is done with too much speed. In addition, strong wave lift and lift on the upwind side of the rotor may make it difficult to stay out of the rotor cloud. This wave descent requires

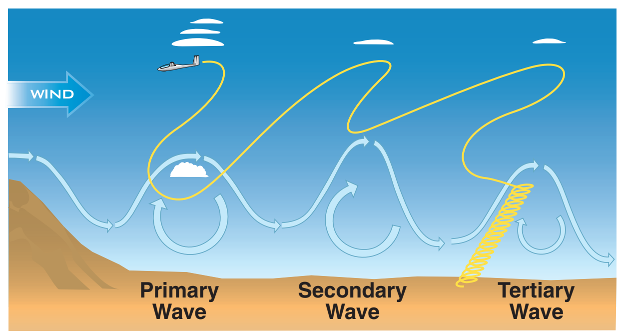

Figure 10-28. Possible flight path while transitioning from the tertiary into the secondary and then into the primary.

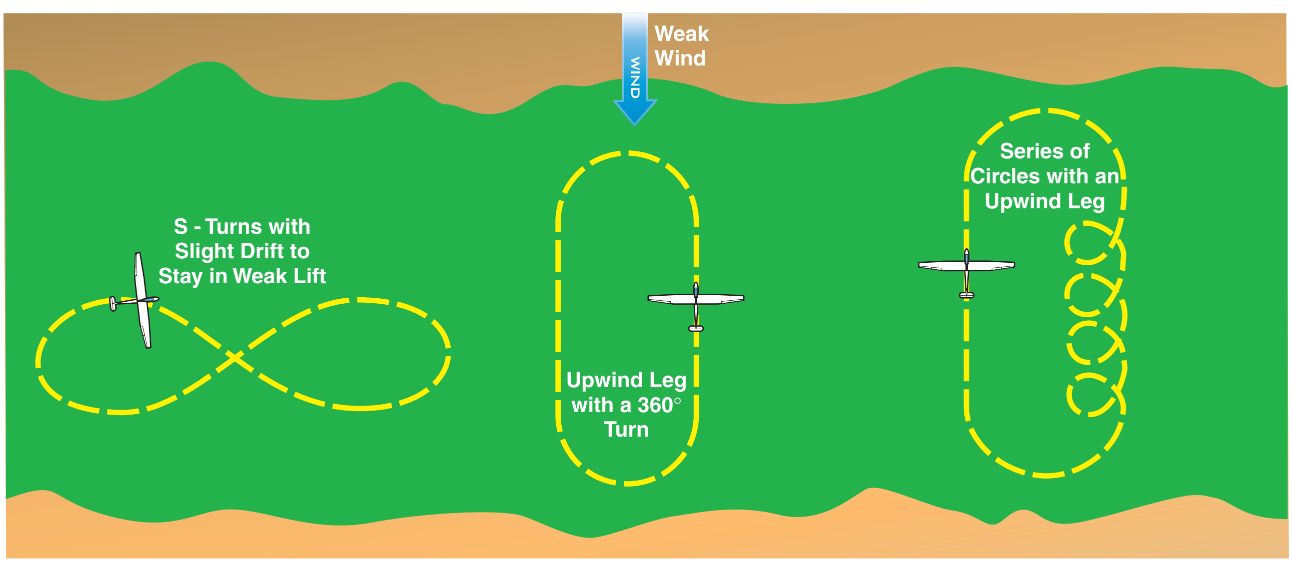

Figure 10-27. Techniques for working lift near the top of the wave in weak winds.

a good deal of caution and emphasizes the importance of an exit strategy before climbing too high in the wave, keeping in mind that conditions and clouds can rapidly evolve during the climb.

Some of the dangers and precautions associated with wave soaring have already been mentioned. Those and others are summarized below.

- If any signs of hypoxia appear, check the oxygen system and immediately begin a descent to lower altitudes below which oxygen is not needed. Do not delay!
- Eventually, regardless of how warmly you are dressed, it will become cold at altitude. Descend well before it becomes uncomfortably cold.
- Rotor turbulence can be severe or extreme. Caution is needed on tow and when transitioning from smooth wave flow (lift or sink) to rotor. Rotors near the landing area can cause strong shifting surface winds—20 or 30 knot. Wind shifts up to 180° sometimes occur in less than a minute at the surface under rotors.
- Warm, moist exhaled air can cause frost on the canopy, restricting vision. Opening air vents may alleviate the problem or prolong frost formation. Clear-vision panels may also be installed. If frosting cannot be controlled, descend before frost becomes a hazard.
- In "wet" waves, those associated with a great deal of cloud, beware of the gaps closing beneath the glider. If trapped above cloud, a benign spiral mode is an option, but only if this mode has been previously explored and found stable for your glider.
- Know the time of actual sunset. At legal sunset, bright sunshine is still found at 25,000 feet while the ground below is already quite dark. Even at an average 1,000 fpm descent it takes 20 minutes to lose 20,000 feet.

SOARING CONVERGENCE ZONES

Convergence zones are most easily spotted when cumulus clouds are present. They appear as a single straight or curved cloud street, sometimes well defined and sometimes not, for instance when a wind field as in Figure 9-30(B) causes the convergence. The edge of a field of cumulus can mark convergence between a mesoscale air mass that is relatively moist and/or unstable from one that is much drier and/or more stable. Often the cumulus along convergence lines have a base lower on one side than the other, similar to Figure 9-33.

With no cloud present, a convergence zone is sometimes marked by a difference in visibility across it, which may be subtle or distinct. When there are no clues in the sky itself, there may be some on the ground. If lakes are nearby, look for wind differences on lakes a few miles apart. A lake showing a wind direction different than the ambient flow for the day may be a clue. Wind direction shown by smoke can also be an important indicator. A few dust devils, or better, a short line of them, may indicate the presence of ordinary thermals vs. those triggered by convergence. Spotting the subtle clues takes practice and good observational skills, and is often the reason a few pilots are still soaring while others are already on the ground.

The best soaring technique for this type of lift depends on the nature of the convergence zone itself. For instance, a sea-breeze front may be well-defined and marked by "curtain" clouds, in which case the pilot can fly straight along the line in fairly steady lift. A weaker convergence line often produces more lift than sink, in which case the pilot must fly slower in lift and faster in sink. An even weaker convergence line may just act as focus for more-frequent thermals, in which case normal thermal techniques are used along the convergence line. Some combination of straight legs along the line with an occasional stop to thermal is often used.

Convergence zone lift can at times be somewhat turbulent, especially if air from different sources is mixing, such as along a sea-breeze front. The general roughness may be the only clue of being along some sort of convergence line. There can also be narrow and rough (but strong) thermals within the convergence line. Work these areas like any other difficult thermals—steeper bank angles and more speed for maneuverability.

COMBINED SOURCES OF UPDRAFTS

Finally, lift sources have been categorized into four types: thermal, slope, wave, and convergence. Often, more than one type of lift exists at the same time. For instance, thermals with slope lift, thermalling into a wave, convergence zones enhancing thermals, thermal waves, and wave soaring from slope lift were all considered. In mountainous terrain, it is possible for all four lift types to exist on a single day. The glider pilot needs to remain mentally nimble to take advantage of various pieces of rising air during the flight.

Nature does not know that it must only produce rising air based on these four lift categories. Sources of lift that do not fit one of the four lift types discussed probably exist. For instance, there have been a few reports of pilots soaring in travelling waves, the source of which was not known. At some soaring sites it is sometimes difficult to classify the type of lift. This should not be a problem—simply work the mystery lift as needed, then ponder its nature after the flight.