

AQUATIC LIFE
OF
LASSEN VOLCANIC NATIONAL PARK

Lassen Volcanic National Park
Mineral, California 96063

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LASSEN VOLCANIC NATIONAL PARK
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INTRODUCTION

Brooks and meadows, waterfalls and meandering streams, springs and pools, ponds and lakes, snowbanks, and even bogs and swampy places--these are some of the water habitats of Lassen Volcanic National Park. Each stands out with striking clarity in offering an opportunity to observe the entire range of aquatic (fresh water) ecology. With such an easily accessible variety of the different situations for living in or near water, this park offers a unique opportunity to study the living things in each kind of dwelling place and the special conditions influencing such distribution of plants and animals.

This will not be an extensive and exhaustive check-list of water life in the park. Rather, the aim is to focus attention on the conditions supporting life in different places and to relate these conditions to the organisms which do live there so the reader -- park visitor may be enticed to explore on his own and add to his appreciation of the biological and physical interactions. Description and illustration are the format instead of detailed and comprehensive listing of all living forms to be seen. As certain physical forces significantly influence the patterns of life in an area, or as certain organisms illustrate such influence, will they be discussed. Many species of transient status could show up on a population count or check-list, but may be left out in this assessing of habitat interrelationships.

Aquatic environments have been arranged into a reasonable scheme, after which a detailed look has been taken at the interaction between physical and biotic factors at work in each situation. Descriptions of Lassen landmarks have been added to enable the reader to find the sites observed and described by the author.

AQUATIC ENVIRONMENTS

It may seem strange to even talk about an aquatic environment for plants and animals in Lassen Volcanic National Park, as we recognize that few organisms live in the absence of water anywhere. Even the scraggly pines in Chaos Jumbles demand water to stay alive. Some life forms, however, can survive only with appreciable quantities of water available to them and are consequently found only in areas where water is present in more abundance. The life on a dry hillside could be included as aquatic -- it isn't, for water though essential, is not the dominating ecologic feature of this area. Thus, aquatic environments may be arranged in a pattern or scale on the basis of how much water is available, or rather, how completely the water portion dominates the visible environment. A flowing stream differs from a quiet lake or pond in the length of time a specific batch of water forms an environment. In one, continual replacement of the water occurs, in the other, stagnation. Each has a distinct bearing on what life can survive in it.

Some situations provide ample water in a state totally or largely unusable by plant or animal. Availability of water takes on importance. Only in its liquid form can water be used by living organisms. Ice and snow, until melted, offer essentially desert conditions and support little or no life.

The fresh water environment may be categorized on the basis of movement. Some waters are quiet, some in motion. Quiet water with little or no flow is called LENTIC from the French and Latin lenis, meaning "calm" or "mild". This includes ponds, lakes, swamps, marshes, bogs and meadows. A snowbank is a temporary quiet water habitat. Sometimes we include a quiet body of water produced by blocking off an otherwise moving situation, and call it an impoundment. A LOTIC environment is one with moving water -- its

name comes from the same word root as the snow-white lotus blossom of Japan, lotic meaning "washed". Included would be rivers, creeks, brooks, and springs. All of these except rivers are in evidence at Lassen Volcanic National Park.

An arrangement of habitats in the aquatic realm would depend, thus, on presence and availability of water and on the movement of the water. Conspicuous bodies of quiet water may be LAKES or PONDS, or perhaps if the lack of flow is due to a barrier made by man or animal, an IMPOUNDMENT. As water becomes less easily seen and plants dominate the visible environment one finds SWAMPS, MARSHES, BOGS and MEADOWS. In the first three of these aquatic habitats the water may be obvious at or very near the surface ^{and} attested to by wet feet when invaded by man or animal, ~~and~~ The fourth is transitional between such wetness and ~~a~~ drier hillsides, ^{is} with Soil becoming increasingly more conspicuous than standing water. Running water habitats may be grouped on the criteria of source and amount of water and on the velocity of the flow. STREAMS may arise from emerging SPRINGS or as drainage ~~run-off~~ from either snow melt or standing water. When fed from springs, a quiet little stream is called a BROOK. Run-off is named CREEK, a name used also as the quiet "babbling" of brooks gives way to noisier flow as several tributaries join into a single stream. When numerous smaller streams join a larger channel the RIVER is formed. The distinctions are decisions of degree and sharp delineation between creek and river is impossible. Lassen's mountain streams are all arising within her own boundaries and have not gathered river stature.

In evaluating streams one may note variation in the velocity or speed of the water movement and classify them in the order of increasing flow or current. A POOL has slow movement through it. With increasing slope or physical gradient to increase velocity it gives rise to the RAPIDS, the CASCADE, and the CATARACT or waterfall. A pool is evident in the present Hat Lake which has so nearly filled in with silt that the entire water mass is slow moving and nearly

stationary. Rapids are seen along many of Lassen's streams including Hat Creek, Manzanita Creek and Summit Creek. Occasional steeper pitches on these streams give rise to cascades. A cascade is present just below the highway as Hat Lake drains through the culvert into Hat Creek and at several points near Kings Creek Falls. Typical waterfalls are seen as Grassy Swale Creek enters Summit Creek above Corral Meadows and at the spectacular Kings Creek Falls.

A convenient key to the classification of Lassen's aquatic habitats is included in Appendix I.

SNOWBANKS

The peaks of Lassen Volcanic National Park form the southern terminus of the Cascade Range. The elevations fall generally between 5,600 feet at Drakesbad in Warner Valley and 10,000 feet at the summit of ~~the~~ Lassen. ^{Pack} Its location at latitude 40°N is sufficiently far north to find snow somewhere in the park for most of the year. In May or June, snowbanks might still be found around Manzanita Lake, and often the park road is closed by heavy snow into the spring.

Snowbanks are temporary aquatic habitats. There is a rapid change as warming weather melts the snow. The moisture laden layer beneath the snow consists of decaying twigs, leaves, needles and other organic matter that was the forest floor before the snow fell. It serves as a transition home for other forms of life. Water is not available while frozen; neither is much left for long after melting is complete. This fact in itself will have bearing on life forms. Only organisms able to take quick advantage of the melting snow will find this a favorable home. The water rich situation appears

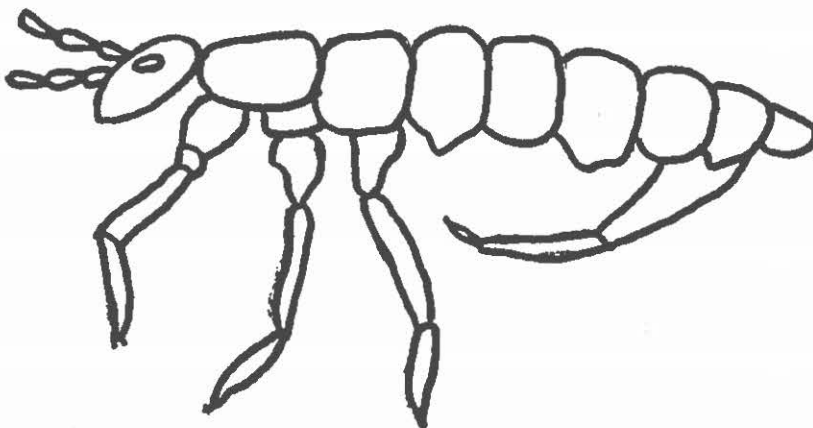
abruptly and lasts for only a little while. The annual sudden display of colorful wildflowers is closely related to a special adaptation for quick maturing in which reproductive success is



Fig. 1 Wildflowers of the Cascade Range

accomplished during the interval while water is available. Many biological similarities exist between a desert and a snowbank. Lassen's slopes abound with many "quick bloomers" that make late June and July so delightful to all who appreciate flowers.

A snowbank itself is sometimes an interesting living place. We hardly expect a large population of any kind where only ice and snow are present. Oh, sometimes a transient fly or bee may be caught (and chilled) as it pauses in its flight, and perhaps a few dormant seeds may be found. Plants and animals just aren't expected to be living on snow -- water isn't available to them. However, as the warming sunshine begins to melt the snow and wetness appears around the edge of the snowbank, both plants and animals begin to show. At the perimeter of some snowbanks may be seen a rim of gray or orange perhaps an inch in width. On close inspection it is found to be a band of uncountable "millions" of tiny insects. They are Collembola or "spring tails". These little insects favor moist places with a good supply of decaying algae, leaves, or moss from which they get their nourishment. As snow melts, the decomposition of the organic base provides adequate food for these insects. They are never large, possibly an eighth of an inch long, but when present in vast numbers they can rim the snow with a colored band. The name "spring tail" comes



from the nature of the insect. Under a magnifying lens one can see that a tiny appendage "tail" is tucked beneath its abdomen. A sudden straightening

Fig. 2 Sketch of a springtail (greatly enlarged)

of this appendage causes a bounce which propels the insect upward and forward. On agitation with a twig or finger at the fringe of the melting snow, one may see them bouncing about. Dr. E. O. Essig¹ called the yellow ones found in Lassen the "Golden snow fleas" (Onychinius cochlei). They do hop about like fleas. Color variants range from orange yellow through metal gray.² Other spring-tails are found in many moist places -- these are unique to the snowbank. They have been seen in June near Manzanita Lake and in July above Summit Lake and at Echo Lake.

The spectacular snowplant is one of the beauties of the Lassen scene. The beautiful red snowplant (Sarcodes sanguinea) is a flowering plant of the Heath or Wintergreen family. It is a saprophyte, living on organic matter provided by fungi living in decaying duff of the forest. During the

winter ^{when} the fungi are not active, for water in liquid form is not available to them, they remain dormant. As the snow melts, the fungi grow in the moist layers of pine needles. Here the snowplant can live. This organism is always associated with melting snow, for its nutrition depends on the success of the fungi which must await the warming and melting. (The picture shown here was taken on the bank of Summit Creek just above Corral Meadow, but numerous places host the snowplant in the



Fig. 3 The Snowplant (Sarcodes sanguinea)

normally (somehow)
 park. It is not found in snow, but is seen very soon after the snow begins to melt. The intertwining of nutritional needs is most interesting. The saprophyte grows only when its food is present after water has become available to its beneficent fungus.

An organism like the "watermelon alga" or "Red snow" is spectacular in early to late summer in the whiteness of Lassen. Large numbers of tiny algae become easily visible because of the brilliant pigments they synthesize. Although this alga is a member of the one-celled Volvocales of the Green Algae it is particularly significant here because of the red pigment it is able to produce. "Red snow" is probably Chlamydomonas nivalis. It is likely that the plants are the only inhabitants living on snowbanks capable of photosynthetic activity. They do have chlorophyll and can build organic molecules from carbon

dioxide and water, getting their energy directly from the sun. Thus, these green algae are producers and are not dependent on a continuing supply of organic matter. They are subjected to a severe hazard of too much radiant

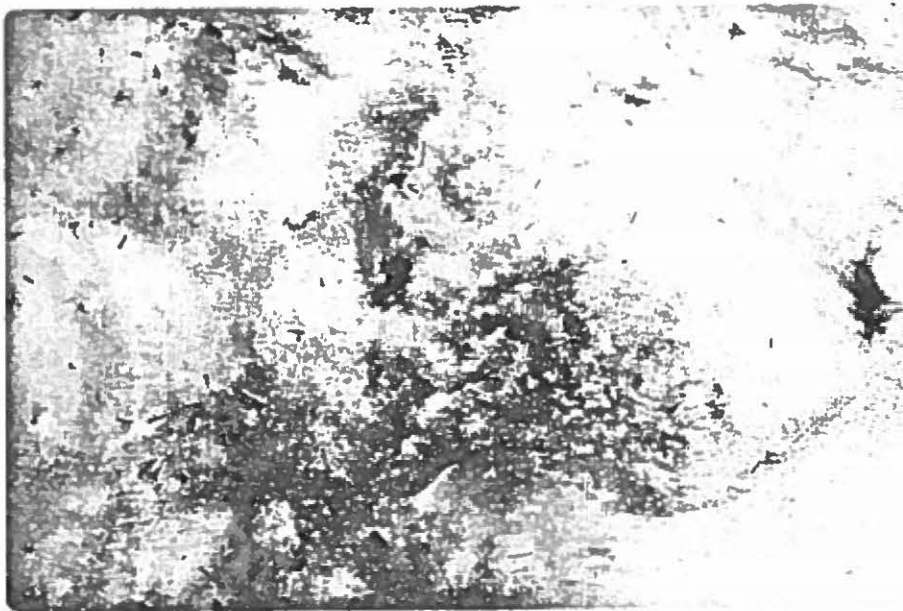


Fig. 4 Red Snow or Watermelon Alga

energy. Were it not for the red pigment protecting them the intense photo energy of the snowbank could block the vital activity of these algal cells. Temperature and moisture probably are the two major environmental factors influencing the distribution of "red snow", but the effect of sunlight cannot be

under rated. Information from the University of Colorado Institute of Arctic and Alpine Research² indicates that color distinction is closely related to the amount of sunlight. Snowbanks shaded for much of the day show green, while those in full sunlight for half a day or more show red color. Orange is found in intermediate exposures. The inconspicuous green color is seldom noticed in observing a brilliantly illuminated patch of snow. The red pigment, karotin, reduces the sun damage to the organisms and at the same time makes the patch on the snow readily apparent to any person. Large colonies of the Chlamydomonas producing this protective pigment exude an odor like that of watermelon. The flavor, too, of snow rich with these algal cells seems to resemble that of the melon. A note of caution: do not eat too much when tasting the snow -- you might be one of the people for whom "red snow" has a marked laxative effect. The slopes near Lake Helen are often ideal places to see this display, even into the month of July.

As the snowbank fades from the Lassen scene other aquatic environments emerge. Some of these are also transient or temporary. Some grade into lasting homes.

¹ Essig, E. O., Insects of Western North America, page 61

² Pollack, Robert, What Colors The Mountain Snow, pages 18 - 20

QUIET-WATER HABITATS

Cold winter conditions bring all quiet waters to a uniformly low temperature differing little at the surface from that near the bottom. Warming days of spring and summer influence surface water far more than that in the depths. The heat of the sunshine is nearly all absorbed surprisingly near the surface, creating a distinct upper layer of warmer water. Since water expands as it is heated, this layer is less dense than the water below it and only a little mixing of the layers occurs. Thus, a two-layered situation can be found whenever the open-water depth is great enough to prevent bottom warming from the sun. Sometimes distinction is made as in the diagram below between an EPILIMNION of warmer water and an HYPOLIMNION of perpetually cold water. The interface between the temperature-labile and the temperature-stable layers is called a THERMOCLINE.

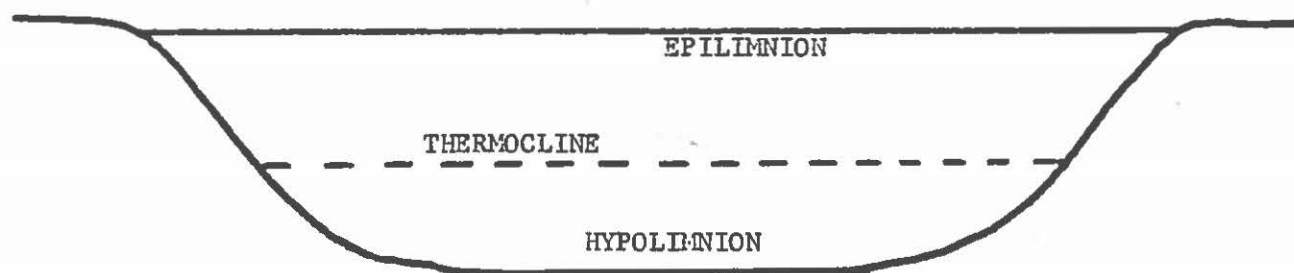


Fig. 5 Thermal stratification of quiet water.

Such temperature stratification is not long apparent in shallow bodies of water. In a technical sense a LAKE displays a true thermocline with a deep cold area that never changes very much in temperature in spite of marked atmospheric change. A body of quiet water without a thermocline would be a POND.

Determination of a thermocline and its level calls for a special thermometer and a boat. Many of Lassen's observers will have neither available. At least an acceptable indication of lake versus pond conditions can be made

on the basis of open water or no open water. If rooted plants or masses of floating plants cover the surface so no really open water is apparent, depths are probably not great and a thermocline would not be present. This would be a POND. If extensive plant free areas may be seen, the fixed plants dependent on sunlight would appear only in shallow areas, and deeper water would be vegetation free. This is the appearance of a LAKE. Such designation requires no special equipment and has been used in grouping the quiet waters of Lassen Volcanic National Park. This means that some of the shallower so-called lakes are really ponds. For many of us a lake is a lake, and that is that. To a careful observer such is not the case at all. The quiet water habitats are varied, and unique features have profound influence on the life to be found.



Fig. 6 Manzanita Lake, one of Lassen's quiet water habitats

Lassen's quiet water habitats have certain physical and chemical elements that encourage specific populations. Already mentioned has been temperature stratification and depth of sunlight penetration. Another factor interrelated to temperature because of thermal influence on solubility of

gases is the availability of oxygen. Water life depends on oxygen fully as much as do land dwellers. However, the level of oxygen in quiet water is low. Warm water can hold far less dissolved gases than cold water for as the gas molecules are warmed they escape more easily from the dissolving medium. Also, running water with considerable churning and aerating stirs more oxygen into the water than in quiet water with minor waves. The oxygen content may be near zero or as great as 25 mililiters per liter of water, but seldom is it greater than 10 mililiters per liter. Even in frothy surface water is it much greater. Oxygen can be absorbed from air, diffusing in at the surface, but this accounts for a probable maximum of only 6 or 7 mililiters per liter of water. Daytime photosynthetic activity of green plants adds the rest. Levels are still far below the 210 mililiters per liter found in atmospheric air containing 21 percent oxygen as used by lung breathers. These values are based on conditions at sea level. They would be less at the altitudes of Lassen.

Surface stirring with wave or cascade action can increase the physical entry of oxygen, but a temperature solubility gradient which inhibits solution in warmer surface water forms a barrier keeping the oxygen content of bottom waters at really pretty low levels. If light can penetrate to enable photosynthetic oxygen production, oxygen demanding forms can live. If not, far fewer organisms will be found, and those that are, will have special adaptations to tolerate the deficient environment. The lack of motion in the quiet water habitats adds to the low levels of available oxygen and accounts for a distribution of life forms in lakes and ponds that differ from those found in moving water. Some will, perhaps, be able to survive in both situations.

Distinction between lake and pond by a thermocline or based on open water has been mentioned. The diagram of a typical lake in cross section and its immediate surrounding areas will introduce some terms used in studying

lakes and ponds and their biologic populations in further considerations of these features.

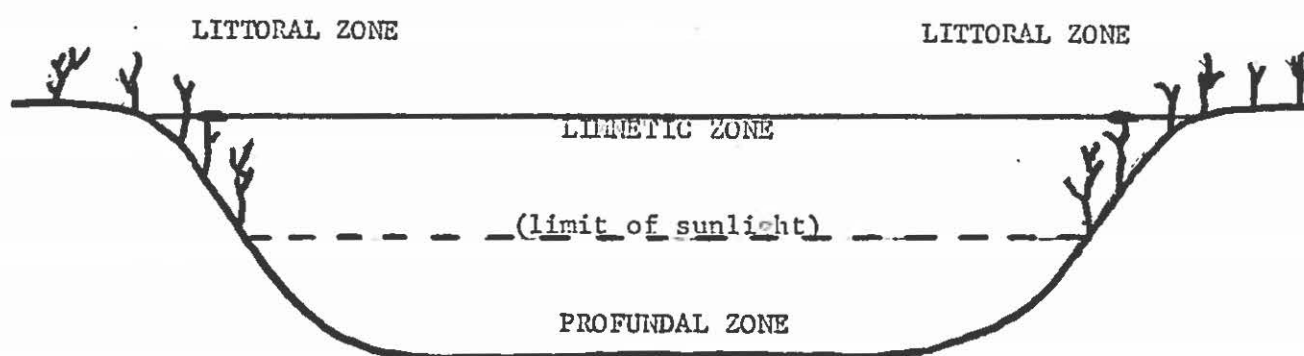


Fig. 7 Life zones found in a typical lake

Three zones are of importance in characterizing a body of quiet fresh water, littoral, limnetic and profundal. The LITTORAL ZONE is an area of water where sunlight penetrates to the bottom. This includes the part with shallow water usually near the shore. If the land - water interface occurs in soils devoid of organic matter such as clean sand or gravel, the boundary is quite apparent and littoral forms are few. However, where rooted plants abound, photosynthetic activity makes this a zone of producers. Then delineation between the shore and the littoral zone is difficult to locate except by identifying the actual land - water line. Many of the water dwellers are rooted in water but grow above the surface and may fall over or mat on the shore, others may never reach the surface of the water. This would make the shore area the littoral zone. If a barely submerged island or "shallows" were encountered it, too, would be littoral.

A LIMNETIC ZONE includes open water near the surface, but only to the depth to which light can penetrate. If the water is clear, it would include the entire non-littoral body if sunlight penetrates the deepest parts.

In this region only floating forms or free swimmers will be found. Rooted and fixed forms belong to the littoral zone. If sunlight can penetrate to the bottom at all parts of a quiet water area, and depth is not so great as to eliminate rooted forms, a limnetic zone may be absent.

When deep water is encountered or turbidity is present with the bottom below the greatest penetration of light, a PROFUNDAL ZONE is observed. Photosynthesis is, of course, absent. Bottom forms are either consumers dependent upon pre-existing organic material or reducers which can derive energy from oxidative processes other than those which involve oxygen, carbon dioxide, and sunlight. Some bacterial decay and decomposition processes represent this kind of activity. Free swimming forms may come and go from this area, using the reducers and the production of reduction processes to fill their own nutritional needs.

Lakes are really only temporary features of the environment--they progress through transition to ponds, then swampy places, marshes, and eventually fill with silt to form meadows. The lake, then, shows a littoral zone, a limnetic zone and a profundal zone. A pond may show only a littoral zone, though sometimes a limnion may seem to be present when only submerged plants not readily visible from the shore cover the bottom areas toward the deeper parts.

Far more delicate and softer organism can be found in quiet water than in running water. The abrasive action and pounding encountered in a rapidly moving stream or waterfall call for protective modifications not required of lake dwellers. In lake or pond, egg masses can be gelatinous, larvae may be delicate, protective cases (as in the caddis fly) may be made of soft twigs and bits of leaves instead of stones, and modifications for holding fast to a given place such as with hooks, mucillaginous secretions, and

suckers are not required. Without much stress the lake offers a fixed home address for many forms. Running water, on the other hand, requires continuing effort or special modifications for organisms to remain long in any one place.

Quiet water presents such physical features as temperature strata, depth of light penetration, amount of dissolved oxygen, and a lack of abrasive and dislocative movement as elements that might strongly influence the distribution of plants and animals.

The littoral zone presents conditions suitable for more forms of life than any other. A good anchorage in muddy bottom, abundant light, enough stirring by surface movement to increase the dissolved oxygen with plants to produce it, and plenty of food combine with a home both physically and chemically stable to make this zone a near perfect dwelling place for a host of aquatic forms. Possibly the biggest problem limiting organisms here is the great competition for essentially identical life situations.

The littoral zone proceeds progressively from the shore through a region in which rooted plants with relatively long stems reach to leaves



Fig. 3 A Littoral zone surrounds Reflection Lake

which float on the surface. Last comes a region of entirely submerged plants which never quite reach the surface. These regions are readily apparent here in the

picture of Reflection Lake.

Most noticeable of the submerged plants are the more lacy members with tiny leaves, the waterweed (Elodea or Anacharis sp.) and the larger leafed pond weed (Potamogeton sp.). Waterweed rises from muddy bottom roots and floats entirely below the surface, forming a welcome shelter for many of the animals of the littoral zone. Conditions are so ideal for this plant that extensive beds fill the lakes and ponds of Lassen Volcanic National Park. Seldom are the blossoms noted, but some tiny inconspicuous ones are sometimes seen topping slender stems reaching the surface. More important in the perpetuation of this kind of plant is the asexual propagation from continued growth of broken off bits below the surface. Snails abound in Elodea sprigs because it furnishes food and because it is one of the most important oxygen producers in the shallow lake and pond. Pondweed grows from bottom roots and while largely submerged often has ^{some} ~~a very~~ few of its topmost leaves on the surface. This is quite easily seen in the illustration. Pondweed is of importance as shelter and food for lake and pond fish, snails, insect larvae, and it is a major part of the food supply for many ducks and other transient water birds.

The yellow pond lilies or water lilies of the family Nymphaeaceae also grow here. Gillett, et al³ describe the yellow water lily (Nuphar polysepalum) as occurring in the ponds and shallow lakes near Manzanita Lake. It is common at Lily Pond, in the unnamed pond above Hat Lake, on Table Mountain, and quite generally in littoral Lassen. Its broad floating leaves and heavy stems serve as home for a variety of other organisms. Found on it are snails, limpets, flat worms, amphibian eggs, insect eggs and larvae of diving beetles, whirligig beetles, caddis flies, damsel flies, dragon flies, and a host of others. Emergent vegetation not seen clearly in the illustration at Reflection

Lake but conspicuous in the area includes sedges, rushes, reeds, cattails, and even shrubby alder and willow. A better illustration of the typical sedge border appears as Fig. 32, a picture taken at a pond on the east ridge above Hat Lake. It shows a rich growth of these plants extending far out from the shore.

The limnetic zone presents a more variable life situation. During the daytime temperatures rise, only to fall again at night. Masses of floating microscopic or near microscopic organisms (plankton) rise as the water warms and sink again as it cools. The surface may appear glassy smooth at times and yet becomes extremely choppy if a breeze blows across expanses of open water. This is a region of change. Communities in this zone character-

istically include the microscopic plankton, plant and animal, some of the more readily visible blue-green and green algae, and a few kinds of free swimming animals.

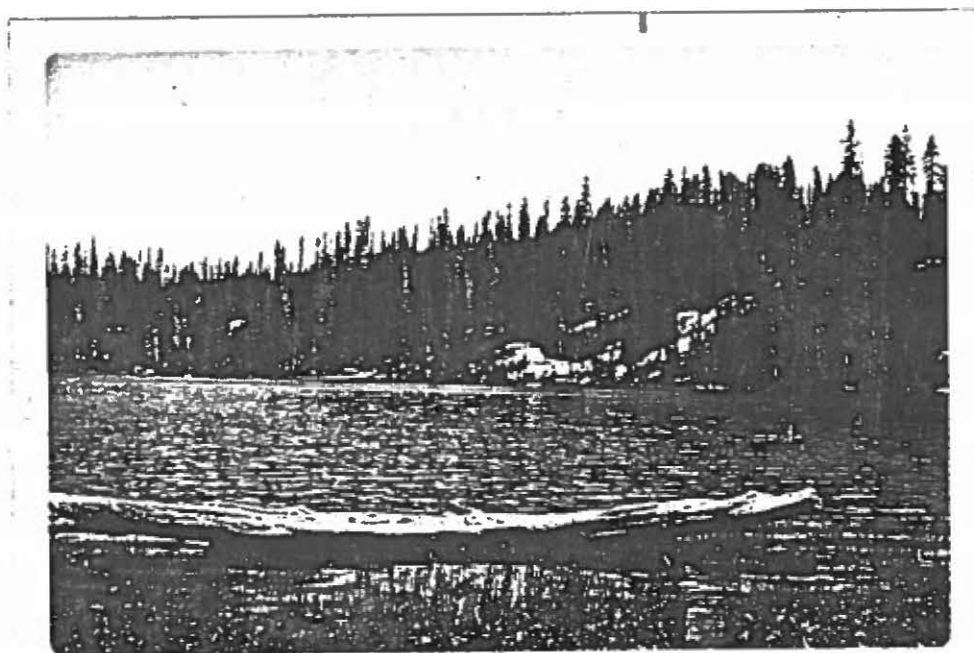


Fig. 9 Echo Lake demonstrates a clear-cut Limnetic Zone. Though tiny and often overlooked, the phytoplankton are extremely important producers. Their number is large and they are continually being kept near the surface where sunlight is most available for their photosynthetic efforts.

They are the food for consumers not able to make their own. Fish are found swimming in many open water areas, feeding on the plankton and insects that may have strayed from the protective vegetation of the littoral zone. Ducks and other waterfowl find the limnion of Lassen's lakes a pleasing stop-over on migration flights, often spending many fall days in the area before the lakes freeze over.

The profundal zone is an oxygen lean area because the surface diffusion and the absence of green plant production provide none. At or near the bottom in the muddy ooze, bacteria and fungi are found. Where they exist the organic remains of limnetic or littoral inhabitants settle to the bottom to furnish rich substrate for the oxygenless metabolic activity of these reducer forms. All the animals (they are limited to only a few species such as chironomid larvae, annelids, and perhaps a few clams) are adapted to spend periods of time with low oxygen and then move out. Some fish penetrate the profundal zone, for it is rich in organic foods, but they can move out for oxygen and do not remain permanently in this zone.

Living forms, whether in the littoral, limnetic or profundal zones may be characterized by their life habits. Organisms which attach themselves to the stems or leafy parts of either emergent or submergent rooted plants are PERIPHYTON such as snails, limpets, ostracods, and flat worms. Those unattached floating forms of sufficiently small mass as to be wafted about by water currents and move up and down as temperatures change are PLANKTON. As examples of plankton one might name numerous algae, rotifers, small crustaceans, and protozoa. Since these are microscopic or near microscopic they will not be seen by the usual park visitor. NEKTON are organisms capable of independent movement, swimming through the water. The nekton include fish, amphibians, swimming insects like aquatic beetles, and even the occasional beaver and otter. A final group includes those organisms limited to surface

life, either swimming on the surface or possibly "striding" on the surface. These are the NEUSTON and include the often encountered water striders, whirligig beetles, and when swimming, even a garter snake.

With this introduction to quiet water ecology, let us examine a few of Lassen Volcanic National Park's many lakes and ponds.

³ Gillett, George, et al, A Flora of Lassen Volcanic National Park, page 83

A FEW OF LASSEN'S LAKES

Several different kinds of lakes are seen within the bounds of Lassen Volcanic National Park.

Manzanita Lake is without a doubt the one most frequently visited by people,

coming to the park. An hour or two spent on the trail around the lake involves one with the challenge of shore ecology at its best.

The shore encompasses sandy beach, pine needle duff, grassy flats, and willow and alder thickets. At selected places one may see the littoral zone in its entirety, noting emergent grasses, sedges,



Fig. 10 Manzanita Lake beneath *Lassen Peak*
~~Mount Lassen~~



Fig. 11 Small littoral islands in Manzanita Lake

and rushes, and submergent waterweed and pondweed. Shallower water permits "islands" of emerging stems and leaves of rooted plants. Open water is present, and often swimming about on the glassy smooth surface ducks and geese are seen. Coots, mallards, and other wild waterfowl find food in abundance in Manzanita Lake. In early October the migrating geese arrive on their southward migration and stay until the lake freezes over. Fish are here and worth the effort of the fisherman. Trout, mostly brown (Salmo trutta), tempt many fishing enthusiasts. Extensive plantings of this species over many years--over 800,000 between

1940 and 1960 -- have resulted in a large population of this fish and its use of available food tends to eliminate lesser species. While Manzanita Lake

is comparatively shallow, prob-



Fig. 12 Sedges, alder, and willow dominate the emergent vegetation on Manzanita's shore

ably about 30 feet deep at most, it presents the character of a typical mountain lake with its three life zones. The thermocline is not distinct, at least during the summer months, according to soundings and temperature measurements made by Paul M. Hubbell⁴ in 1961. He found summer surface temperatures ranging from 64° to 68°F., and 8°F. higher than bottom temperatures with a steady temperature reading of 56°F. below 12 feet. The cold

bottom below a thermocline is not present in Manzanita Lake because of the shallowness of the water. Light penetrates nearly to the bottom except in the deepest



Fig. 13 The "quack-quack" of the mallard is a common sound around Manzanita Lake

parts, so the profoundal zone

is not extensive. Hubbell's observations showed surface oxygen at about 9 parts per million (6.4 mililiter per liter) and deep water levels of just over 10 parts per million (7 mililiter per liter). These oxygen levels can support trout at all depths in the lake.

It seems doubtful, however, that Manzanita Lake is able to sustain an ever-increasing population of trout, or for that matter even hold its own. The 1961 study indicated relatively poor catches by fishermen in spite of heavy plantings. Spawning areas are limited -- a short stretch of Manzanita Creek alone supplies suitable flow and gravel for this important process.

Reflection Lake, though similar in many respects to Manzanita Lake, very closely resembles a pond, particularly in its eastern end. The large shallow area is an extensive littoral zone with sunlight penetrating to the bottom and bottom attached plants are in evidence most of the way across the lake. Fish thrive in the protected hide-a-ways of Elodea and pondweed, and

can be seen ranging in size from fingerlings of a couple of inches to six or eight inch trout. Coots (mudhens) and ducks often call this area their temporary home. The



Fig. 14 Reflection Lake shows no open water at its eastern end

western end of the lake is not

unlike Manzanita Lake, for it demonstrates considerable open water with a far more narrow shore area. It is about 15 feet deep.

Its pseudo thermocline is at a depth of 12 feet leaving only 3 feet of cooler thermo-stable water. In Reflection Lake the summer bottom temperature is a degree or two above 60°F. The 1961 report indicated for this lake a population of 93 percent brown bullhead (Ameiurus nebulosis) 1.5 per cent brown trout, and 0.5 percent rainbow trout (Salmo gairdneri). Following Mr. Hubbell's census, recommendations were made for eliminating the bullheads and subsequent stocking with rainbow trout. ^{This was done in 1963.} There is no documentation of a follow-up study. Of fish taken now by anglers, rainbow are most frequently reported and these are the only fish commonly seen from the shore. The view of the shallow portion of Reflection Lake seen from the Lily Pond trail where this trail veers away from the lake, gives an ideal composite for recognizing the chief features of a typical littoral zone.

Lassen Volcanic National Park, located in a part of California that was marked by extensive glacial action, shows many small pocket lakes (tarns) which were gouged out by the glaciers. A delightful collection of these are the Sifford

Lakes. The pocket left by the glacial gouge fills with snow. Sometimes the term "snow-melt" lake is applied to it.

If sufficient water remains when the first rain and snow of the autumn begins the re-filling, they may be year around lakes. If percolation and evaporation takes too heavy a drain, the basins may dry up.



Fig. 15 One of the Sifford Lakes -- a tarn



Fig. 16 A shallow pocket lake of glacial origin

They are far more barren lakes than those like Manzanita Lake. The water is cold, and the substrate usually rocky. Mineral solution is not great. Life in the warmer surface stratum is not abundant. The water is clear, transparent. One can see bottom even to a considerable depth. These are OLIGOTROPHIC lakes. Bottom ooze is negligible because the limnion has produced very limited populations of organisms which could have settled to the bottom to form this ooze. Ponds and lakes rich in upper stratum life such as Manzanita and Reflections Lakes would be EUTROPHIC and are less likely to be temporary as are some of the oligotrophic lakes.

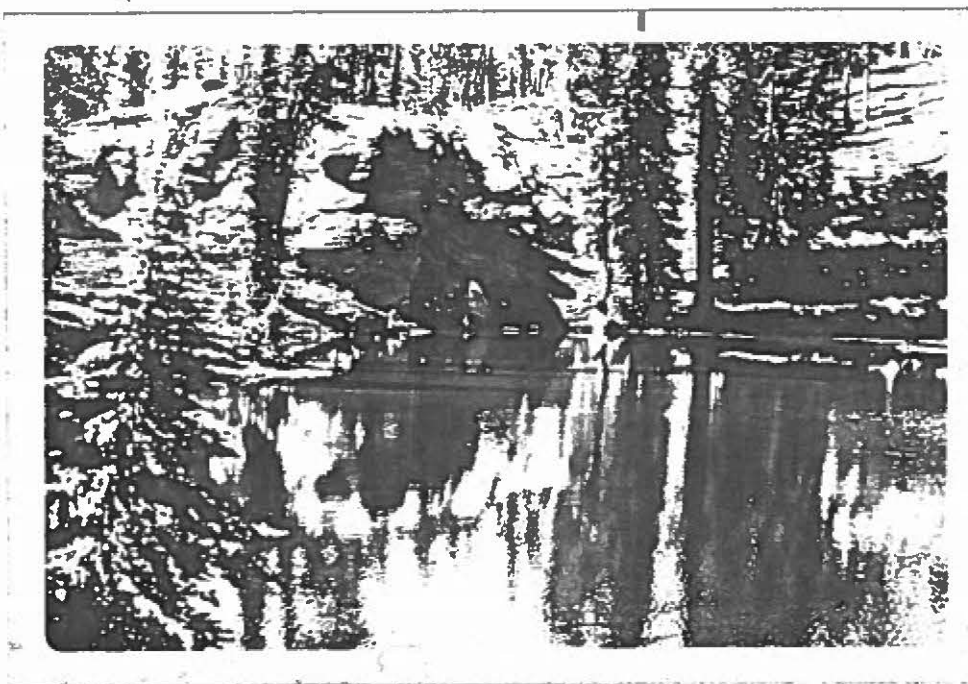


Fig. 17 An Oligotrophic lake -- one of the Sifford group

Some green algae grow in the glacial basin lakes when they thaw. Fish are scarce or absent. Littoral zones are narrow, if indeed, they are present at all
Whirligig

beetles, a few diving beetles, sometimes mosquito larvae comprise the usually observed forms, as temperatures permit. Strikingly, these are not rich lakes. To the connoisseur of scenic beauty they are lovely; to the biologist they offer a meager population of living things.

On the moist banks of the Sifford Lakes, early July bring in- to blossom the pink heather (Phyllodoce breweri) with another showy pink blossomed plant, the mountain laurel (Kalmia polifolia). The white heather (Cassiope mertensiana) with its dainty white bells also appears in July on the shore of several of the Sifford Lakes. These three plants appear on the



Fig. 18 One of the Sifford tarns that held too little water to last the year around



Fig. 19 Pink Heather on the shore of a glacial tarn. rocky shores of the glacial tarns between 7000 and 9000 feet. Echo Lake and Summit Lake show some of the features just mentioned.

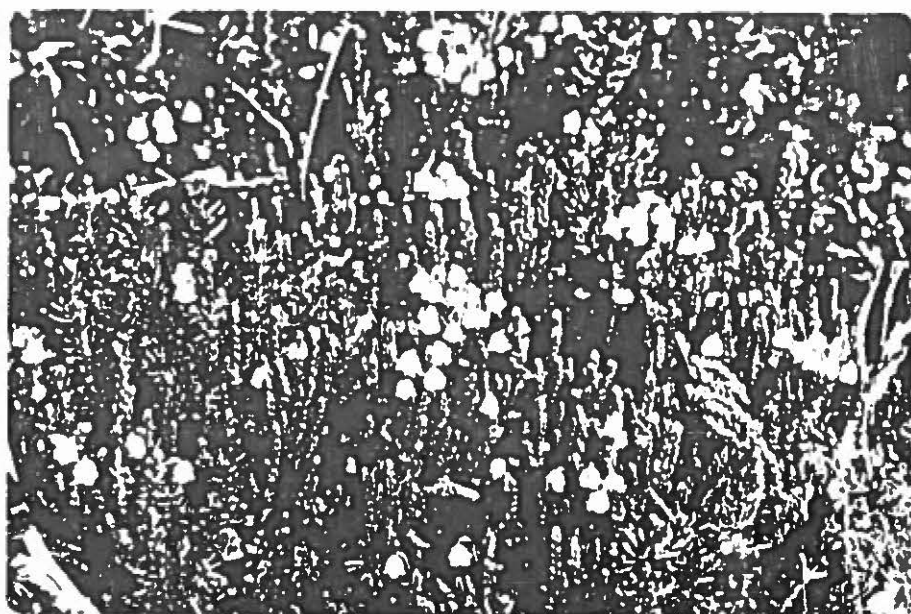


Fig. 20 Bells of White Heather (Cassiope mertensiana)



Fig. 21. Emerald Lake, a deeper glacial lake

The lake is near the 8000 foot level and may have snow around it until well into July and sometimes into August. Of particular note is the presence of

Lake Helen and Emerald Lake are also glacial lakes, but they differ strikingly from the snow lakes of the Sifford group. These two lakes are deeper and larger, and do not dry up during the summer. Emerald Lake, as its name indicates, shows a deep green color. (It has been planted with rainbow trout, and apparently provides adequate organic food to sustain them.)

OMIT
FISH LAKE
BRAIN REMOVED

algae in the littoral zone during the warmer period. Green algae clouds the limnion and produces the green color of the lake (a bright orange form shows in the illustration).

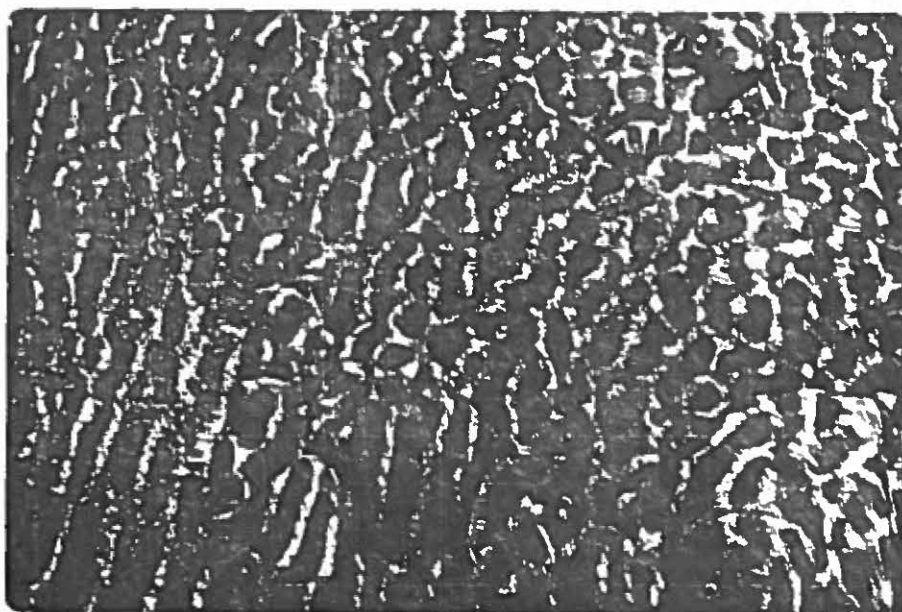


Fig. 22 Algae growing near the shore of Emerald Lake

The more typical pondweed and waterweed found in many lakes is totally absent, and the shore area appears exceptionally barren. Probably the cold water and the dearth of mineral nutrients combine to limit the more general plant



Fig. Lake Helen, another deep glacial lake

growth, and without the supporting plants, a few aquatic beetles will be all the insect life usually seen.

Lake Helen is even more spectacular

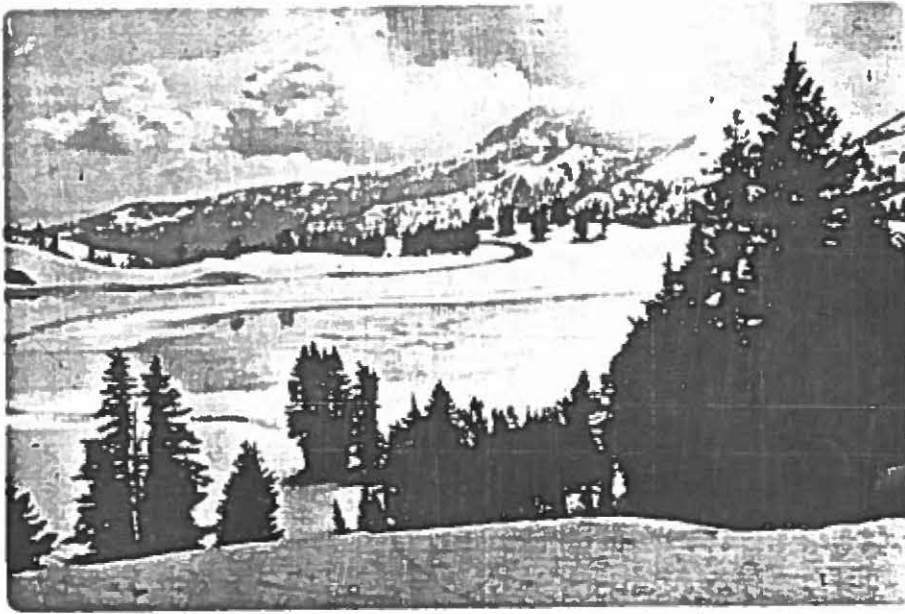


Fig. 24 Lake Helen is often frozen over and covered with snow

because of the scarcity of living things. It is deep and blue with clear transparent water. This is a splendid example of a lake with a distinct hypolimnion, for the deeper

water temperature varies only slightly between summer and winter. It is maintained at a constant 39°F. the year around. Often frozen over and covered with snow for all but the hottest summer months, only a very limited organismal population is ever seen. The littoral forms include a meager colony of green algae, a few water beetles, and not much else. Probably because of the limited food available and possibly because there may be toxic minerals in the water, attempts to

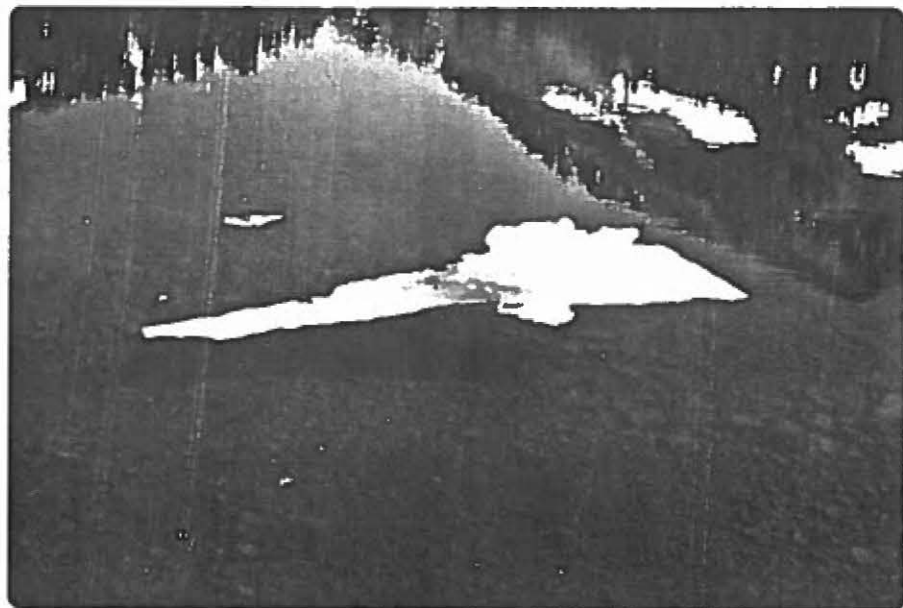


Fig. 25 The littoral zone of Lake Helen is strikingly free of plant or animal life

stock Lake Helen with trout have proved unsuccessful. It seems likely that sufficient oxygen would be in solution to support the fish in limited number, but they do not survive. This easily accessible lake in summer, then, provides enjoyment as scenery rather than a favorable home for much aquatic life.



Fig. 26 Hemlock Lake shows open, clear limnion with a barren littoral zone



Fig. 27 Summit Lake has many similarities to the Sifford group and other tarn lakes

Many other lakes are found in Lassen Volcanic National Park. Some have names, many remain unnamed. Some are Eutrophic like Manzanita, many are Oligotrophic like the Sifford

Lakes. Some are rich in flora and fauna, some are exceptionally lean. Others closely resemble ponds rather than lakes. Thus Lassen provides the aquatic biologist with ample areas for studying the living things of the LAKE habitat.

⁴Hubbell, Paul M." A Survey of Manzanita and Reflection Lakes", pages 1-59