Fryxell, R. 1965. Mazama and Glacier Peak volcanic ash layers: relative ages. Science 147: 1288-1290.
Lyford, W. H. Jr. 1947. The morphology of the brown podzolic soils of New England. Soil Sci. Soc. Amer. Proc. (1946) 11:486-492.
Poulson, E. N., F. A. Mark, and G. Gibbs. 1939. Soil survey of Bonner County, Idaho. USDA Bur. of Plant Ind. Series 1934, No. 16, 66 pp.
Powers, H. A., and R. E. Wilcox. 1964. Volcanic ash from Mount Mazama (Crater Lake) and from Glacier Peak. Science 144:1334-1336.
Raney, F. C. 1948. Contrasting effects of *Thuja plicata* and *Tsuga heterophylla* litter on soil in a mixed forest. M.S. Thesis. The State College of Washington, Pullman. 22 pp.
Rigg, G. B. and H. R. Gould. 1957. Age of Glacier Peak eruption and chronology of post glacial peat deposits in Washington and surrounding areas. Am. J. Sci. 255:341-363.
Ross, G. J., and M. M. Mortland. 1966. A soil beidellite. Soil Sci. Soc. Amer. Proc. 30:337-343.
Secor, J. B. 1956. Soil characteristics in relation to certain forest types in the northern Rockies. Ph.D. Thesis. The State College of Washington, Pullman. 165 pp.
Soil Survey Staff. 1951. Soil Survey Manual. U.S. Dept. Agric. Handbook No. 18. Agric. Res. Service, Wash. D.C. (Supplement, 1962).
Western Regional Soil Survey Work Group. 1964. Soils of the Western United States. Washington State University, Pullman. 69 pp.
Wilcox, R. E. 1965. Volcanic-ash chronology, p. 807-816. *In* H. E. Wright, Jr., and D. G. Frey (ed.), The Quaternary of the United States, Princeton University Press, Princeton, New Jersey.

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Field Observations on the Altitudinal Distribution of the Side-Blotched Lizard[1]

The geographical range of the North American desert-dwelling side-blotched lizard, *Uta stansburiana*, extends northward (46° N Latitude) to the sagebrush steppe region of southeastern Washington (Stebbins, 1954). Although *U. stansburiana* is active on the soil surface throughout the winter months in the southerly Mojave Desert (37° N Latitude), it is dormant during winter in the steppe region of Washington (Rickard, 1967). Presumably the Washington population of lizards is near its latitudinal cold tolerance limit. Within the regional climate of southeastern Washington it is expected that increasing elevations, with associated cooler temperatures, would limit the upslope distribution of this lizard.

The Study Area

The study area is the northeast facing slope of the Rattlesnake Hills located on the Atomic Energy Commission's Hanford Reservation, Benton County, Washington. Here, over a linear distance of approximately eight miles, the elevation increases from about 500 feet on the basal plains to more than 3500 feet along the crests of the Rattlesnake Hills.

Methods Employed

During 1966 and 1967, a pitfall trap survey was made along an elevational transect to determine the ecological distribution of ground-dwelling beetles. During this survey, records were also kept on the number of lizards, *Uta stansburiana*, caught in the can traps. These records provide the source of data used in this paper.

Eight locations were selected along the elevational gradient. At each location there were five can traps arranged in a line with three-meter spacing between traps. The sites were visited weekly from April, 1966 to December, 1967. The insects were removed and killed for identification, but the lizards were released near their sites of capture.

From April to December, 1967, weekly maximum and minimum air temperatures were taken at a height of three decimeters using a U-type thermometer mounted on a vertical post shaded from direct insolation by wings of styrofoam plastic.

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Vegetation

Throughout the elevational range of this study, the vegetation is dominated by only a few species of desert shrubs (Table 1). Big sagebrush, *Artemisia tridentata,* is widely distributed and provides most of the ground cover. The amount of ground covered by shrub canopies ranged between 7 and 28 percent with the lowest canopy coverages at the high elevations. Shrubs are absent on one site (No. 5) because of a fire that occurred in the summer of 1957.

TABLE 1. Ground cover (%) provided by shrubby species (line transects) at eight locations along an elevational transect in the Rattlesnake Hills 1967.

Taxa	*Elevation in feet*							
	460	530	630	925	1470[1]	2500	3100	3450
Artemisia tridentata	5.9	17.7	24.7	10.8	0	7.1	9.7	10.4
Purshia tridentata	1.8	10.4	0	0	0	0	0	0
Chrysothamnus vicidiflorus	0	0	0	0	0	0	1.2	4.0
C. nauseosus	5.5	0	0	0	0	0.3	1.2	0.3
Grayia spinosa	0	0	2.0	0	0	0	0	0
Salvia dorii	1.2	0	0	0	0	0	0	0
Erigonum niveum	5.2	1.2	0	0	0	0	0	0
TOTAL % COVER	19.6	28.3	26.7	10.8	0	7.4	12.1	14.7

Agropyron spicatum

——————Extent——————

Poa secunda

——————————Extent——————————

[1] Shrubs destroyed by fire at this site in the summer of 1957 and still absent from the site.

The understory consists mostly of grasses. Sandberg blue-grass (*Poa secunda*) is abundant and ubiquitous, but bluebunch wheatgrass (*Agropyron spicatum*) is found only at elevations above 900 feet. When present, wheatgrass dominates the understory and generally provides more ground cover than the associated shrubs. Cheatgrass brome (*Bromus tectorum*) is widespread and dominates the understory of disturbed sites, but contributes significantly to ground cover only at the low elevation sites No. 1 and 2.

During the past 20 years grazing by livestock has been light with most of the grazing confined to stands in the mid-elevational ranges.

Results and Discussion

For two consecutive years, the catch of *U. stansburiana* showed an upper altitudinal limit between 925 and 1470 feet (Table 2). It was anticipated that temperature would be

TABLE 2. The trap catch of Side-blotched Lizards along an elevational gradient in the Rattlesnake Hills 1966-1967.

	Site Number								
	1	2	3	4	5	6	7	8	Total
	Elevation in Feet								
	460	530	630	925	1470	2500	3100	3450	
1966	24	15	2	29	0	0	0	0	70
1967	10	31	7	20	0	0	0	0	68
Total	34	46	9	49	0	0	0	0	138

an important environmental factor in determining the upslope boundary of lizards. Air temperatures measured near the ground and recorded at weekly intervals during the active season showed an expected decrease with increasing elevation (Table 3). However, the difference in temperature between location No. 4 (925 ft.) and location No. 5 (1470 ft.) was not great enough to explain readily the up-slope limits of lizards. It is likely that summer temperatures are warm enough even at the highest elevations to sustain the physiological activities of lizards. For example, at site No. 8 (3450 ft.) maximum air temperatures ranged above 75°F for 21 consecutive weeks.

TABLE 3. The monthly catch of side-blotched lizards from pitfall traps 1966 and 1967.

	1966	*1967*
March	—	0
April	2	3
May	2	2
June	1	1
July	2	6
August	8	15
September	23	26
October	30	15
November	2	0
TOTAL	70	68

It seems likely that the critical season for lizard survival is during the winter month: when they retreat to the soil. The depth of soil could then be of great importanc to lizard survival. A shallow soil would not allow sufficient depth below the penetra tion of sub-freezing temperatures. However, the soil depths at sites 4 and 5 are botl covered with at least one meter of fine textured (silt loam) soil. The most obviou difference is the absence of shrubs on site 5. However, it doesn't seem likely that th demise of sagebrush in itself would account for the absence of lizards because lizard did not occur at the higher elevations which do support sagebrush.

The peak of the lizard catch occurred in September and October (Table 4). Th increase in catch is largely due to the influx of foraging juvenile animals into the popu lation. The late appearance of juveniles limits the amount of time that the environ ment is favorable for foraging before the onset of winter dormancy (Rickard, 1967) It is possible that increasing elevation with decreasing temperatures (Table 3) coul directly affect foraging by curtailing above-ground activity or indirectly through th dormancy of important insect foods.

Although the results presented are derived from a general field survey and the up slope distribution of side-blotched lizards may be somewhat different along other trar sects in the Rattlesnake Hills, it seems clear that *U. stansburiana* provides a populatio useful for the study of interrelationships of environment (abiotic and biotic) and th distribution of a poikilothermic vertebrate near the northern limits of an extensiv geographical range.

Summary

A pitfall trap survey of an elevational transect in the sagebrush steppe region of soutl eastern Washington showed the upslope extent of *Uta stansburiana* populations as som where between 925 and 1470 feet. The observed changes in air temperature and veget tion along the transect are briefly discussed in relation to the distribution of lizards.

TABLE 4. Weekly maximum air temperatures °F at eight locations along an elevational gradient in the Rattlesnake Hills 1967.

Date	Sites 1	2	3	4	5	6	7	8
4/17	78	76	77	73	70	60	66	60
4/24	80	76	76	78	71	78	63	61
5/1	77	74	77	74	73	58	66	64
5/8	88	87	86	84	81	72	74	73
5/15	98	94	93	91	89	78	79	76
5/22	107	107	105	103	98	92	91	88
5/29	100	100	99	96	92	—	82	82
6/5	98	99	98	96	95	82	80	78
6/12	102	102	102	97	96	84	84	80
6/19	114	109	109	108	104	99	96	93
6/26	113	112	104	106	106	102	98	95
7/3	112	112	111	112	106	101	100	98
7/10	116	116	114	116	111	105	96	100
7/17	117	118	116	116	112	106	100	102
7/24	110	112	110	110	106	103	99	96
7/31	112	112	110	110	106	96	96	96
8/7	112	112	110	112	106	101	99	97
8/14	116	114	114	116	111	116	102	100
8/21	119	118	116	117	114	108	106	105
8/28	107	110	106	106	104	96	97	95
9/5	114	113	112	112	110	94	96	100
9/11	105	102	......	102	100	......	......	91
9/18	103	102	100	100	98	96	95	90
9/25	106	104	103	101	100	89	92	91
10/2	101	98	96	95	95	......	......	78
10/9	84	85	85	85	82	76	82	79
10/16	83	85	84	73	80	70	74	73
10/23	79	79	76	76	76	55	57	68
10/30	68	72	71	69	67	63	64	61
11/6	82	84	81	79	77	76	68	67
11/13	67	68	65	63	60	50	57	58
11/20	66	65	62	65	65	59	60	53
11/27	67	67	66	67	64	......	60	58
Average	97.0	96.5	94.8	94.2	91.7	85.0	83.2	82.0

Literature Cited

Rickard, W. H. 1967. Onset of winter dormancy in lizards and beetles. Northwest Science 41:92-95.

Stebbins, R. C. 1954. Amphibians and reptiles of North America. McGraw-Hill Book Company, Inc., N.Y. 536 pp.

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Froth Flotation for Harvesting *Chlorella* Algae

In recent years, considerable research has been directed toward finding a feasible method for the mass harvesting of unicellular algal suspensions. The benefits of such an economical process would be tremendous in the area of food production, as algae have a high protein value. Nutrient removal and recovery would be an added benefit because algae have a high nitrogen-phosphorus composition. Many methods have been investigated, including dissolved-air flotation, flocculation and sedimentation, and centrifugation. Thus far, however, none of these methods has proven economically feasible, especially when an end product suitable for human or animal consumption was desired.

This study was initiated to investigate the possibility of using froth flotation as a method of algal harvesting and was carried out in conjunction with a dairy waste project being conducted at Washington State University's Knott Dairy Farm. The dairy waste project involves various methods of treatment of dairy manure wastes. The final treatment step consists of a polishing lagoon in which *Chlorella vulgaris* is the dominant algal form. The influent to this pond is rich in nutrients which become concentrated in the algae cells. Removal of the algae would be highly desirous since their discharge into any receiving water would constitute a significant organic loading on the stream. The additional benefit of algae harvesting could then be realized by the use of the recovered product as an animal food or crop fertilizer, thus creating a semi-closed nutrient system.

In the initial study, water samples containing the algae were brought to the laboratory and tested. These samples were observed to froth quite readily, probably as a result of a natural frothing agent produced by the *Chlorella vulgaris* itself.

Later, the effects upon harvest efficiency by the variation of certain parameters such as (1) pH, (2) temperature, (3) addition of a frothing agent and (4) frothing dosage were investigated.

Mechanism of Froth Flotation

Froth flotation is a highly complex phenomenon involving numerous parameters. These parameters include concentration of material to be frothed, temperature, oxygen content of the solution, types of frothers and their concentrations, and pH. Although mineral froth flotation has been practiced for over fifty years, it is still regarded by many workers as an art rather than a science.