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INTRODUCTION: The terrestrial-mollusc faunas of Europe and North America have received a good deal of attention from professional biologists and hobbyists alike. Relatively little attention has been directed toward the study of ecological relationships. The present study is, therefore, devoted to environmental relationships of land snails in certain northern forest associations. The work was carried out in the region of Itasca State Park, Clearwater County, Minnesota.

Boycott (1929) carried out one of the early ecological investigations on land snail requirements. He concluded that land snail distribution was independent of the biotic community, but was determined by the physical environment. Jacot (1940) supported this hypothesis, findings that alkaline regions supported the most abundant and varied terrestrial-mollusc populations. The results of other workers are in conflict with these conclusions. Foster (1937) found that areas of high soil moisture, available food materials and ground cover produced the greatest number of *Polygyra thyroides*. Van Cleave and Foster (1937) further found that this species is limited to areas which support growths of certain succulent plants.

Archer (1939), Strandine (1941), Oughton (1948), Lee (1952) and Burch (1955) have presented evidence that one cannot relate land snail distribution to either biotic or physical influences, independent of one another. Such conditions interact in determining the distribution and limitation of any particular species. Archer demonstrated a correlation between certain plant associations and land snail species, however, few snails were found on acid soils regardless of vegetation. Strandine found *Succinea ovalis* most abundant when leaf mold was most abundant. His population reached its low when the soil was most acid. Lee's results with *Stenotrema hirsutum* were quite similar. He found this species most abundant in areas where the soil pH was between 7.5 and 8.5. However, snails were found in such areas only if decaying wood was present.

Burch, in a rather sophisticated evaluation of soil mineral contents in relation to land snail abundance, showed a direct correlation between the number of land snails and calcium, magnesium, and potassium in the soil. As the content of these minerals increased, the number of snails increased. No snails were found where the soil calcium content was below 0.019%. Soil organic matter was also found to be positively correlated with land snail abundance. High phosphorus concentrations produced a negative correlation. Land snails were found to be most abundant where the soil pH was between 6.3 and 7.2.

The relationships between land snail populations and fire, age of forest stands and environmental temperature have been evaluated. Jacot (1935) found that fire produced no lasting effects on land snail populations. Henderson (1936) demonstrated differential mortality in snail populations due to fires. The differences were found to be due to differences in microhabitats of the different species of snails.

The age of a forest stand plays no part in determining the level of land snail populations according to Jacot (1935); a questionable conclusion if plant succession is considered in relation to soil formation.

The existing environmental temperature must be taken into account in evaluating populations of snails such as *Anguispira alternata*. Under conditions of low temperature (4° C) Jones (1935) found this species to burrow into the ground. This could lead to erroneous estimates of the existing population.

One would not expect to find the same species of land snails on a grassland as in a coniferous forest. If some of the same forms did extend through such habitat diversity the population levels supported in the various habitats would most likely not be the same. This has been demonstrated by several workers including Basch, Bainer and Wilhm (1961). The point to be considered in the present study is the distribution and abundance of snails in a forested area, i.e. a study of microhabitats. The work was carried out in a geographically limited area in order to eliminate any major climatic variation.

Methods: The basic sampling techniques used in the two parts of the study were similar in nature but different in application. In the first study land snail populations in four reasonably pure forest stands were sampled and compared. The sampling areas were chosen on the basis of their representing forest associations typical of the area. These were: *Pinus banksiana, Pinus resinosa, Populus tremuloides-Acer saccharum-Tilia americana,* and *Populus tremuloides-Abies balsamea.*

In each area a 20-meter line was marked out and divided into 1-meter segments. Forty quadrats were established by using both right and left sides of the line. Four of these 1-meter square quadrats were sampled at random.

Snail populations in the quadrats were evaluated by screening all of the material above the packed soil. The material collected was screened twice (the top mesh

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6 x 6 mm., the second level 1 x 2 mm.). The intact shells in both the separated material and screenings were collected for later identification. Information regarding plant species, stand ages, canopy density, leaf mold abundance, etc. was gathered at the same time.

In the second study snail populations in a well defined vegetational transition were sampled. Again the study area was selected based upon its floral characteristics. The site of this study was the basin of Mary creek near the outlet of Mary lake. The flood plain supports a hardwood stand of *Ulmus americana* and young *Acer saccharum* with an understory of *Cornus stolonifera*. These species are replaced in the surrounding forest primarily by conifers. The transition includes a zone of *Abies balsamea* and *Populus tremuloides* which ultimately gives way to *Pinus resinosa* and *Pinus strobus*.

A 100-meter line was laid out in this area in such a manner that it started in pine, ran through the transition into the flood plain hardwood stand, crossed the creek and reversed the sequence. Sample plots were established at 20-meter intervals along the base line yielding a total of 6 stations. At each of these points stations were also established 5 meters north and 5 meters south of the base line. Thus a total of 18 stations were established.

Sampling was carried out in the same manner as in the previous study except that the material which passed through the lower screen was not examined. The snail fauna thus lost was evaluated in a separate sampling in which one quarter of each of 3 quadrats in 3 vegetation types — pine, balsam-aspen, and elm-maple — was exhaustively sampled.

Soil acidity in these plots was measured with a LaMotte-Morgan soil test kit. Elevations of the sampling stations were measured using the south end of a nearby culvert (through which Mary creek passes under Park Drive) as the base level.

Snails were identified to genus using Baker (1939), Pilsbry (1940, 1946, 1948) and Eddy and Hodson (1957). Dawley (1955) was used as a preliminary checklist of forms to be found in the study area. Since variation in total population levels was the prime consideration the snails were not identified to species. All intact shells were included in the counts because of the difficulty in determining whether or not the smaller forms were alive. Plant names follow *Gray's Manual of Botany* (1950).

Results: The number of snails of each genus taken from the four distinct forest associations are shown in Table 1.

Red pine stands do not seem to provide suitable habitat for the land snails of this area. No snails were taken in sampling 4 quadrats in a red pine stand. The aspen-basswood-maple stand yielded the largest number of snails. This association also was found to have the greatest accumulation of leaf mold.

The jack pine stand supported the next largest snail population. This may have been due to a heavy herb and shrub undergrowth. About half as many snails were found per quadrat in the jack pine as in the aspen-basswood- maple association. However, 2 more genera of snails were found in the fir-aspen stand than in the jack pine in spite of the greater number of individuals in the jack pine. *Discus* was quite abundant in the fir-aspen samples but totally lacking in the jack pine samples. Nearly all of the snails found in the jack pine were of the genus *Zonitoides*. Burch and Archer both reported *Zonitoides* to be a very widely distributed form (with regard to habitat). The localization of snails in the various forest stands was quite similar to the results reported by Archer where comparison was possible.

TABLE 1. Results of Sampling in Four Forest Associations.

Genus of Snail	Abundance of Snails (per 4 sq. meters) Jack Pine	Red Pine	Aspen-Basswood-Maple	Fir-Aspen
Retinella and *Zonitoides*	101	0	159	30
Discus	0	0	70	25
Helicodiscus	0	0	5	2
Strobilops	4	0	26	1
Totals	105	0	265	59
Average No. of Snails per Square Meter	26.3	0	66.3	14.8

All of the snails taken in sampling 4 quadrats in each forest association were pooled and the final counts made on the total sample.

The second part of the study was carried out in an attempt to determine the more intimate relationships between snail populations and habitats. Six 1-meter square quadrats were sampled along a transect through the forest transition described earlier.

TABLE 2. Elevations of Sample Stations in Transition

Station No.	Elevation in Meters from Base Level
1	5.2
2	1.8
3	1.1
4	1.0
5	2.0
6	3.5

Elevations were measured using the south end of culvert under Park Drive (through which Mary creek passes) as the base level.

Station 1 was located midway on a rather steep slope in coniferous forest. Station 2 was at the foot of this slope in a mixed hardwood-coniferous zone. Stations 3 and 4 were on flat ground in the flood plain deciduous stand. Stations 5 and 6 were on a gradual slope, the former in a mixed stand and the latter in conifers. The elevations of the stations from the creek level are found in Table 2.

The results of sampling the 6 previously described quadrats are found in Table 3. Again it can be seen that the conifer stands (here mixed conifers) yielded far fewer snails than did the mixed hardwood-conifer stands or the pure hardwood stands. The mixed conifer stands were not barren as was the pure red pine stand. The taxonomic diversity of snails was again much greater in the hard-

TABLE 3. Numbers of Land Snails found in various Areas in a Forest Transition.

Genus of Snail	Conifer	Mixed	Hard-wood	Hard-wood	Mixed	Conifer
	Number of Snails (per 1 square meter)					
Station No.	1	2	3	4	5	6
Retinella and *Zonitoides*	74	148	105	34	62	50
Euconulus	0	0	0	0	7	0
Anguispira	0	4	1	8	0	0
Discus	27	55	46	9	43	7
Helicodiscus	0	0	3	0	0	0
Gastrocopta and *Vertigo*	0	0	2	6	0	0
Strobilops	54	17	15	9	0	0
Vallonia	1	81	22	211	4	0
Cionella	0	0	213	106	2	0
Totals	156	305	407	383	118	57

The stage in the transition at each station is listed along with the genera of snails and their abundance in a sample from one quadrat, 1 meter square.

wood samples than in the pure conifer samples. Snails were more abundant in the samples from all areas in the transition than from the 4 forest associations discussed previously.

The sample from Station 6 yielded far fewer snails than did the sample from Station 1 in spite of both being in areas of similar vegetation (conifers). Two obvious differences were noted. Station 1 was on a steep slope while Station 6 was on a gradual slope. The soil at Station 6 was more acidic (pH 5.5) than that at Station 1 (pH 6.5). Soil acidity tests were run at each of the six sampling stations in the transition and the results are given in Table 4.

Table 4. Soil pH's at each Sampling Station in the Forest Transition

Station No.	Forest Type	Soil pH
1	Conifer	6.5
2	Mixed	7.0
3	Hardwood	7.0
4	Hardwood	7.5
5	Mixed	6.5
6	Conifer	5.5

The term "Mixed" is used here to refer to a mixture of hardwood and coniferous forest species.

The most acid station (No. 6 pH 5.5) yielded the smallest number of snails. However, Station 4 with the most alkaline soil (pH 7.5) did not yield the largest number of snails. The stations with near neutral soils were found to yield the largest samples of snails. Since these estimates were based upon single samples the small variation between the near neutral and alkaline areas may be random. The overall trend toward reduced numbers of snails on acid soil did seem obvious.

These data do not completely agree with those of Burch who found snails to be most abundant on slightly acid soils (pH 6.3-6.7). The same forms were found in both studies. Lee reported *Stenotrema hirsutum* to be most abundant where the soil pH was 8.0. This form seems to require a more alkaline soil than the forms taken in the present study.

The discrepancies among the studies considered may lend additional support to the contentions of Burch, of Van Cleave and Foster and of Strandine that a series of interacting factors such as soil calcium, moisture, food materials, and ground cover interact to determine land snail population levels. This is a direct contradiction of the findings of Boycott, and to some extent those of Jacot. The obvious explanation is that general characteristics of the habitat (forest vs. grassland, etc.) determine the possible types of microhabitats. An interaction of more subtle conditions determines the suitability of microhabitats to any particular snail. Acid soils do not support many land snails under any mitigating conditions.

Measurements of soil pH or of forest associations would seem to be reasonable indicators of expected land snail populations and their compositions in the region studied. These conditions are obviously not the only ones which determine population levels and composition but are effective in a relative evaluation.

The validity of disregarding material which passed through the fine mesh screen was tested in work in the forest transition. The snail fauna thus lost was found to be inconsequential in the samples from the 4 forest associations. A control was carried out in an attempt to get complete counts on snails of all sizes in the transition. Due to the difficulties involved only quarters of a square meter quadrat were thus sampled. These samples were taken from the secondary sample stations north and south of the base line, at Station 6 and south of the base line at Station 4. This allowed a sample from the coniferous zone (6-south), the mixed conifer-hardwood transition (6-north), and the hardwood zone (4-south). The results of this sampling are found in Table 5.

Based upon the results of these control counts it was

TABLE 5.

Genus of Snails	Abundance of Snails (per ¼ Square Meter) 4-South	6-North	6-South
Retinella and *Zonitoides*	225	121	86
Hawaii	102	0	0
Euconulus	24	56	35
Striatura	29	0	2
Anguispira	1	0	0
Discus	187	63	14
Helicodiscus	297	0	0
Gastrocopta and *Vertigo*	73	15	1
Columella	33	0	0
Strobilops	65	13	0
Vallonia	173	9	1
Cionella	287	1	0
Carychium	441	0	0
Totals	1937	278	139
Number per Square Meter	7748	1112	556

Station 4-south was located in hardwoods, 6-north in mixed conifer-hardwood, and 6-south was in conifers. The number per square meter was calculated by multiplying the sample by a factor of 4.

clear that considerable numbers of snails were being lost through the lower screen. This did not alter the results in regard to the relationship between relative abundance and floral association but did alter the absolute population level estimates. In addition four genera were being lost (*Hawaii, Striatura, Columella and Carychium*). The population levels based upon these total counts seemed fantastically high. Dead shells did not by themselves inflate the counts since it was estimated that over 50% of the shells examined contained live snails.

It is interesting to note that of all the snails found only *Euconulus* was as abundant in the samples from the conifers as from the Hardwoods. However, *Euconulus* was not taken in any of the samples in the 4 distinct forest associations. The largest number of individuals of this genus were taken in the mixed hardwood-conifer zone of the transition. *Carychium, Hawaii, Helicodiscus, Anguispira, Columella, Cionella* and *Striatura* were all drastically reduced in number in the mixed hardwood-conifer zone compared with the population sample levels taken in the pure hardwood zone.

The *Zonitoides* and *Retinella* group was again found to constitute the dominant group of snails in the pine stand.

It is thought that more extensive sampling in various forest associations (especially hardwoods) will reveal the presence of some of the small forms which were taken only in the transect through the transition.

Discussion: Based upon the results obtained in the present study and in previous studies reported in the literature it seems clear that relative abundances of land snails can be correlated with the presence of certain forest associations. This relationship is most likely determined at the level of soil formation, food availability, cover, moisture, calcium availability and degree of slope. Well defined numerical differences in land snail population levels were found in sampling four distinct forest stands in a geographically limited area.

The transect study demonstrated that the snail populations changed as the vegetational characteristics in the transect changed. Most of the snail genera did not extend beyond the pure hardwood stand. The limitation to deciduous stands with near neutral or alkaline soils was not true of all of the generea of snails. *Zonitoides* and *Retinella* were found to be moderately abundant in the mixed forest and conifer stands (exclusive of red pine). This also seemed true in the case of *Euconulus*. The limitation of this form to the collections from the transect could be due to the proximity to water. This supposition is based upon Baker's description of the habitat requirements of this form.

Land snails were found to be more abundant in the Mary creek basin than on higher ground in areas of similar vegetation. Measurements of soil moisture should reveal if the presence of Mary lake and creek make this a more moist area.

The influence of slope needs further study. It was not possible to separate many of the environmental factors one from another as they varied in a parallel fashion. Much work remains to be done before the microhabitat requirements of land snails can be fully described. More complete samplings will make statistical evaluations possible.

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LITERATURE CITED

ARCHER, A. F. 1939. The Ecology of the Mollusca of the Edwin S. George Reserve, Livingston County, Michigan. *Occ. Pap. Mus. Zool. Univ. of Mich.* 398:1-34.

BAKER, FRANK COLLINS. 1939. *Fieldbook of Illinois Land Snails.* Ill. Nat. Hist. Surv. Manuel 2. 166 pp.

BASCH, P. F., PHILIP BAINER and JERRY WILHM. 1961. Some Ecological Characteristics of the Molluscan Fauna of a Typical Grassland Situation in East Central Kansas. *Amer. Midl. Nat.* 66:178-199.

BOYCOTT, A. E. 1929. The Oecology of British Land Mollusca, with special Reference to those of ill-defined Habitat. *Proc. Malac. Soc. London.* 18(5):213-224.

BURCH, J. B. 1955. Some Ecological Factors of the Soil Affecting the Distribution and Abundance of Land Snails in Eastern Virginia. *Nautilus.* 69(2)62-69.

DAWLEY, C. 1955. Minnesota Land Snails. *Nautilus.* 69:56-62.

EDDY, SAMUEL, and A. C. HODSON. 1957. *Taxononic Keys.* Burgess Pub. Co., Minneapolis, Minn. 141 pp.

FOSTER, T. D. 1937. Productivity of a Land Snail, *Polygyra Thyroides* (Say). *Ecology.* 18(4):545-546.

FERNALD, M. L. 1950. *Gray's Manual of Botany*, 8th ed. American Book Co., N.Y. 1632 pp. lxiv.

HENDERSON, JUNIUS. 1936. How Some Snails Survive Grass Fires. *Nautilus.* 50:71.

JACOT, A. J. 1935. Molluscan Populations of Old Growth Forests and Rewooded Fields in the Ashville Basin of North Carolina. *Ecology* 16:603-605.

JACOT, A. P. 1940. The Fauna of the Soil. *Quart. Rev. Biol.* 15:28-58.

JONES, DAVID. 1935. Burrowing of Snails. *Nautilus.* 48:140.

LEE, C. B. 1952. Ecological Aspects of *Stenotrema hirsutum* (Say) in the region of Ann Arbor, Mich. *Amer. Midl. Nat.* 47(1):55-60.

OUGHTON, J. 1948. A Zoogeographical Study of the Land Snails of Ontario. *Toronto Studies, Biol. Ser.* 57:1-126.

PILSBRY, H. A. 1940. Land Mollusca of North America (north of Mexico). *Acad. Nat. Sci. Phila. Monog.* 3. 1(2)575-994.

PILSBRY, H. A. 1946. *Ibid.* 2(1):1-520.

PILSBRY, H. A. 1948. *Ibid.* 2(2):521-1113.

STRANDINE, E. J. 1941. Quantitative Study of a Snail Population. *Ecology.* 22(1):86-91.

VAN CLEAVE, H. J. and T. D. FOSTER. 1937. The Seasonal Life History of a Land Snail, *Polygyra thyroides* (Say). *Nautilus.* 51:50-54.