FINAL REPORT

CONTRACT NO. 29000-37835
MINNESOTA "SUCCINEA
CHITTENANGOENSIS" SURVEY

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INTRODUCTION

In 1983 two Minnesota sites for an unusual succineid land snail, tentatively identified as Succinea chittenangoensis (Pilsbry, were found in Fillmore County, Minnesota. Subsequent visits in the summer of 1984 to the previously known Simpson Sedum integrifolia leedyi site in Olmsted County resulted in the discovery of a third Succinea colony. Another field trip to an algific talus slope discovered the preceeding year on Deer Creek in Fillmore County indicated the possibility that S. "chittenangoensis" was present there also.

Accordingly, a survey of all probable sites for the succineid was undertaken between May 1 and June 1, 1985 in Fillmore and Olmsted Counties. Previously known sites were resurveyed to establish population size of the snail. As two of these were located adjacent to algific slopes, the 20 or so sites discovered in 1983 were also reexamined. Because two very rare plant taxa (S. i. leedyi and Draba arabisans) were known to be associated with the snail and were of interest in their own right attempts to locate addtional populations of them were made also.

A total of twelve days were spent in the field. At various times I and my field assistant Jeff Dickson were accompanied by Heritage botanist Welby Smith and by University of Minnesota bryologist Jann Janssens.

FIELD METHODS

As in the original U.S. Fish & Wildlife Service survey that located most Minnesota algific sites (Frest, 1983), geologic criteria were the prime determinants for site selection prior to the actual field work. All Minnesota algific slopes and maderate cliffs occur in part of the Middle and Upper Ordovician section, i.e. the Dunleith, Wise Lake, and Dubuque Formations in or near the periphery of the Paleozoic Plateau ("Driftless Area"). U.S.G.S. 7½' topographic maps in the known outcrop area of the relevant units (Fillmore and Olmsted Counties in Minnesota) were scanned to locate N facing well-forested steep escarpment edges and major stream incisions at appropriate elevations. Elevations were determined by field examination of the section and corrected periodically for dip and facies changes. About 50% of all sites visited proved to be valid picks.

On larger algific sites and the largest maderate cliffs a litter sample consisting of one 11" x 17" duck bag was collected by handfuls over the whole of the site. The approximate area of the critical habitat was hand surveyed and recorded. For targeted plants, rough sight counts were made of fully grown individuals based on visible yearly shoots. It is presumed that each adult Sedum has an average of 24 flowering stems and each adult Draba 12 offshoots. Litter were processed for snails using standard methods.

RESULTS

Five additional live sites for the succineid were located, two with very large populations. Three of the new sites are in Fillmore County, two in Olmsted. As it seemed unwise to litter sample small sites, population estimates are necessarily tentative (see Table 2). The largest site was litter sampled; about 10,000 adults were alive in 1985. There were some indications that populations fluctuate considerably from year to year.

One Olmsted County site produced only a few dead shells and may no longer support a live population; shell material collected appears to be subfossil. Live material for electrophoretic analysis by Elaine Hoagland (ANSP) and for anatomical study by George Davis (ANSP) was collected from two sites and hand delivered to Philadelphia. Preliminary results of these analyses have recently been received (E. Hoagland, pers. comm., June 12, 1986) and will be discussed in a following section.

In addition, algific talus slope sites were also noted and collected. Six new localities, four in Fillmore and two in Olmsted County, were briefly collected for both plants and snails. The latter constitute the most northerly algific sites. Two new and very sizeable sites for Sedum integrifolium leedyi were found in Fillmore County. Draba arabisans, formerly reported from two sites in southeastern Minnesota, was located at four more, one in Olmsted and three in Fillmore County, all associated with live or subfossil succineids.

In summary, nine maderate cliffs were located in southeastern Minnesota. Subjective rankings of these forpreservational purposes are given in Table 3. Population estimates for the three known Sedum and six known Draba sites are listed in Table 1. Detailed descriptions of localities and their associated relict flora and fauna are in Appendices 1 & 2. Site maps, drawn on U.S.G.S. 7½' topographic base maps, were prepared both for new and previously discovered algific and maderate sites (Appendix 3). As an aid to seeking eventual protected status for them, suggested fencing or tract boundaries for the sites and their associated sink and fissure systems are indicated in red on the maps.

While the possibilities for algific sites in Minnesota have not been exausted, it is considered unlikely that many additional sites for S. "chittenangoensis," Sedum, or Draba will be found in southeastern Minnesota. The most likely two remaining localities, not visited because of weather conditions in 1985, will be searched in July or August of 1986. Similar maderate sites were discovered in 1985 in Iowa. Only 11 were found, some of which had relict snails but none Sedum or Draba. The Minnesota sites remain the best, and a particularly rare and unique aspect of Minnesota natural history deserving of especially diligent preservational efforts.

SYSTEMATIC STATUS OF SUCCINEA "CHITTENANGOENSIS"

As originally found in 1983 the shell morphology of the Minnesota maderate cliff succineid was unlike any other described American species with the exception of S. chittenangoensis (Pilsbry), reported only from a single New York site. The collection of much new material in 1985, including some live specimens, has done much to clarify the status of both the New York and Minnesota-Iowa succineids. Results are as yet preliminary and unpublished, but enough is now known to allow evaluation of the Minnesota populations. A joint publication of the anatomical, electrophoretic, and morphometric studies of Davis, Hoagland, and Frest respectively is anticipated.

Anatomical studies by Davis indicate that S. chittenangoensis is indeed specifically distinct from S. ovalis. Electrophoretic studies tend to confirm this. The material shipped to Davis and Hoagland by Frest was subdivided into two forms by Frest on shell morphology. This Minnesota snail also appears distinct from ovalis on both anatomical and enzyme data, but is also distinct (although closely related to) from S. chittenangoensis. Morphometric data collected by myself from both Iowa and Minnesota populations confirms the existence of two shell forms, with few intergrades, in both states. The bulk of the Minnesota specimens belong to one morph (1 in the tables and appendices), while the bulk of the Winneshiek Iowa specimens are morph

2.

A preliminary consensus is that both forms are subspecies of a single new taxon related to but distinct from both S. ovalis and S chittenangoensis. Additional live material of morph 2 is needed to confirm this, but the few live Minnesota specimens of it from Minnesota do appear to be subspecifically distinct from morph 1 in anatomy and isoenzymes as well as in shell morphology. No additional specimens of morph 2 should be collected from the Minnesota populations, as all are very small; Iowa populations could take the collection pressure for this morph, but not for morph 1, which is rare to very rare there.

It is recommended that a petition be submitted as soon as practical for seperate listing as federally Endangered species of both forms. Examination of the succineid collections of the Field Museum, University of Michigan Museum of Zoology, Ohio State University Museum of Zoology, Academy of Natural Sciences of Philadelphia, Harvard Museum of Comparative Zoology, and the U.S. National Museum of Natural History. indicate that the new species is distinguishable even if only shell morphology is considered, no mean factor considering its usual unreliability in this group. Proper iniatiators would be either or both the Endangered Species Coordinators or Nature Conservancy personnel in the affected states. A similar petition should be undertaken for Sedum integrifolium leedyi, in this case involving both New York and Minnesota organizations. Pending formal placement on the federal list, state listing should be carried out. Research on the snail sites should be conducted carefully and the sites should be monitored judiciously for signs of population changes. No research destructive of the major part of any population should be allowed.

Some peculiarities of the succineid should be noted. Observation of captive specimens indicates that the life span definitely exceeds one year, unlike some other succineids. At all sites dead shells outnumber living ones by a very large factor, suggesting that large year to year fluctuations in number are possible. In the three seasons in which this taxon has been observed, very few live specimens were found at any site at any one time except under unusually favorable conditions. These are at dawn and dusk after thunderstorms or heavy rain, particularly in May or October. Eggs were seen in late May and early June, and juveniles one to one and a half months later. Young specimens, presumably from one years' hatching, were most commonly seen in late September-November. These were never more than one quarter of the full adult size. Large sized adults were never common. Examinations of extensive late Woodfordian loess and Woodfordian and Holocene alluvial deposits has turned up a few localities with fossil specimens. None have been seen from Illinoian or earlier deposits with comparable faunas and ecology, such as the Petersburg Silt. Occasional abundant finds were made in colluvial slopes estimated at between 18,000 and 14,500 YPB; one such is present at MN 40, where a large population still lives. Other fossil sites lack living specimens.

MADERATE CLIFFS

The preferred habitat for the succineid and for Sedum in Minnesota has been termed a maderate cliff by me previously. The coinage implies the presence of an actively dripping cold water syetem likely duplicating some portion of the species' glacial habitat. Genesis is very similar to that of algific slopes.

Both are believed to have originated near the end of the Pleistocene, i.e. in late Woodfordian times (ca. 14,500 YBP) when the last glacial lobe was at its maximum extent in Iowa and Minnesota. The close approach of the Des Moines Lobe to the Paleozoic Plateau at that time induced well-known periglacial features (now associated with tundra and taiga) and phenomena, especially near the W edge of the Plateau. The algific slopes and maderate cliffs are fossil remnants of periglacial conditions. The talus slopes are oversized and oversteep compared to those formed in the Holocene or forming today, and are held in place largely by their own soil. Fissures are shallow and not much affected by solutional phenomena, unlike the better-known caves and caverns. The latter occur in solutional karst in different geologic units in the same area. Those of the algific slopes and maderate cliffs are mechanical karst, penetrating less into the surrounding terrain and not linked to as extensive a groundwater system. The fissures are a result of ice-wedging of large blocks slipped out a short distance along incompetent units such as shales or bentonites. The large associated soil-covered taluses are fossil congelifractate slopes.

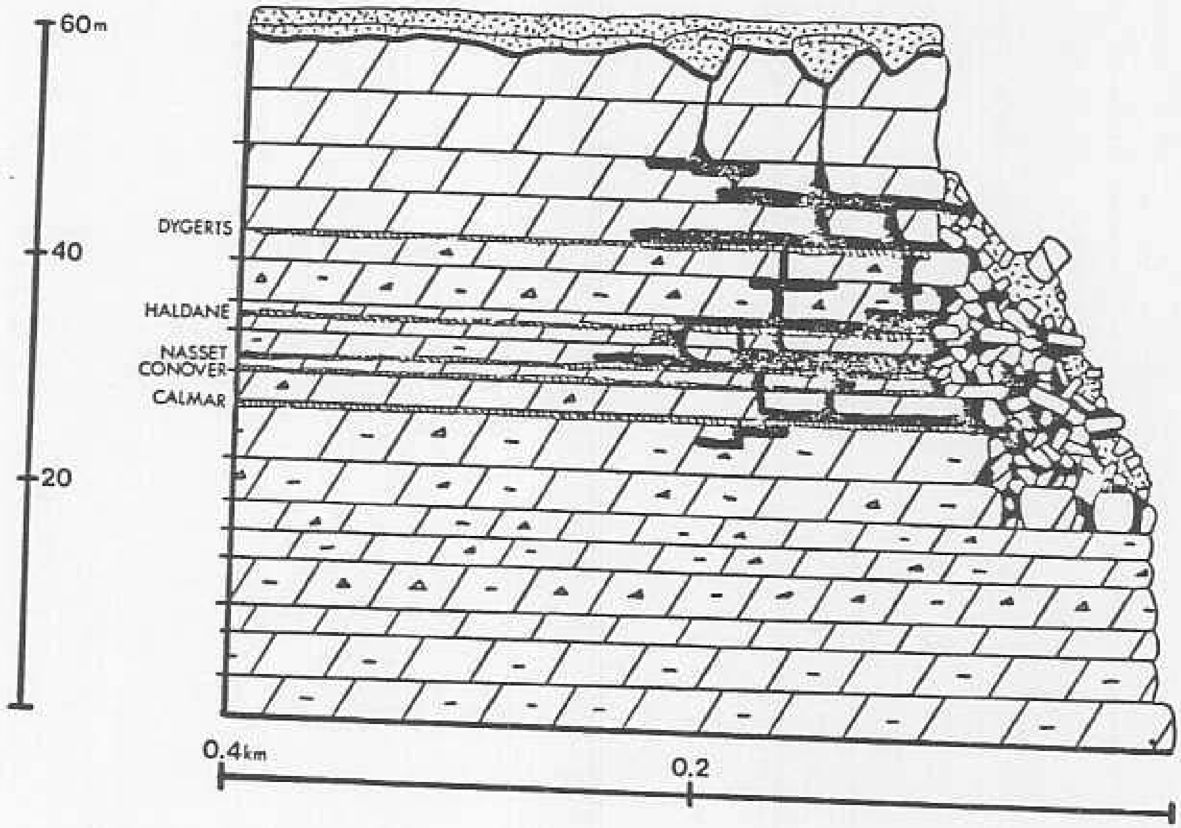
Both occur in Minnesota in the same geologic units, namely a limited part of the middle-upper Ordovician section near the edge of the Plateau margin. As is typical of some periglacial features in modern environments, they formed preferentially on north-facing steep slopes, e.g. those along the edges of natural escarpments and deeper stream valleys. The preferred units have some common characteristics. They generally consist of a thick-bedded carbonate unit with a thin soil cover in a karst region with solutional as well as mechanical sinks, underlain by a series of thinner carbonates with naturally partly impervious thin intervals (such as shales, bentonites, or cherts) interbedded. Generally, a much thicker and more impervious shale unit underneath largely cuts off the system from deeper groundwater circulation. Sinks and vertical fissures develop preferentially in the thick carbonate, while the thinner shaly or bentonitic unit is the main contributor to the talus. Horizontally arranged fissures occur preferentially in the thinner-bedded carbonate, almost always along the bentonites or shale layers. The bentonitic portions of the Dunleith and Wise Lake Formations are especially suitable (Figure 1). If a sizeable talus formed or remains to cover the fissure system, an algific talus is the result. If the original configuration lacked talus, the result is a maderate cliff (Figure 2). Maderates, not surprisingly, often occur on the outside portions of the meanders of actively eroding streams. It is likely that the present physiography closely represents that present for the bulk of the time since the site's formation. Nevertheless, maderate cliffs can be seen as the ultimate end of all algific talus sites, if sufficient time elapses. In effect they are algific sites without an extensive ice reservoir, either because the talus and horizontal fissure component was originally weakly developed due to less severe periglacial effects locally, or because the talus and part of the fissure system was subsequently eroded away. Nearly all of the maderates found to date seem to fit into the former category: at most sites, the effects of erosion in the last 14,000+ years may have been minor. The present flora and fauna of both site types could not have lived there when the site was first formed (it was too cold, and at least some of the taxa are known to have been some distance to the south). However, the rapid deterioration of glacial climates in the period 14,000- 12,000 YBP enabled some of the glacially-adapted biota to the south to migrate quickly into the area before the return to interglacial conditions made most of it unsuitable.

Both maderate cliffs and algific slopes thus represent a very unlikely set of historical and physical congruences for their existence and biota, one that is unlikely to occur elsewhere in any given glacial.

SUMMARY

Nine sites for maderate cliffs and about twenty algific talus slopes occur in a limited portion of Fillmore and Olmsted Counties. They are limited in number and frequently delicate microhabitat for a variety of Northern and glacial relict species rare elsewhere or endemic to the sites. Among snails, notable endemics are V. hubrichti and Succinea n. sp. Notable relicts or disjuncts include Vallonia gracilicosta and Discus catskillensis. Among plants, the near endemic S. i. leedyi (one site in New York) and Chrysosplenium ioense are especially notable. The disjunct Draba arabisans and many other algific slope plants are characteristic parts of the flora. Both site types are the product of the area's geologic history and its recent glacial history interacting in an as yet unique way. Such sites, because of their limited area and number, status as glacial and northern refugia, remarkable history, and fragility are deserving of special protection. Because of their very recent discovery, their climate, ecology, flora, and fauna are as yet poorly known, but should be carefully investigated and preserved intact.

FIGURE 1. Cross section (upper) and edge-on outside (lower) views of algific slope complex as seen in SE Minnesota. Lower figure shows stratigraphy and distribution of algific patches (dotted) and vent openings and fissures (black). Note tendency for algific portions to group into distinct levels along bentonites. Upper figure shows terminology for bentonites, penetration of fissure system (black) into rock and talus and dirt cover. System includes sinks on upland, vertical and horizontal fissures along joints and bedding planes (often bentonites) and largely open internally but soil covered congelifractate talus accumulated over fissures. Ice collects in horizontal fissures and in portions of talus.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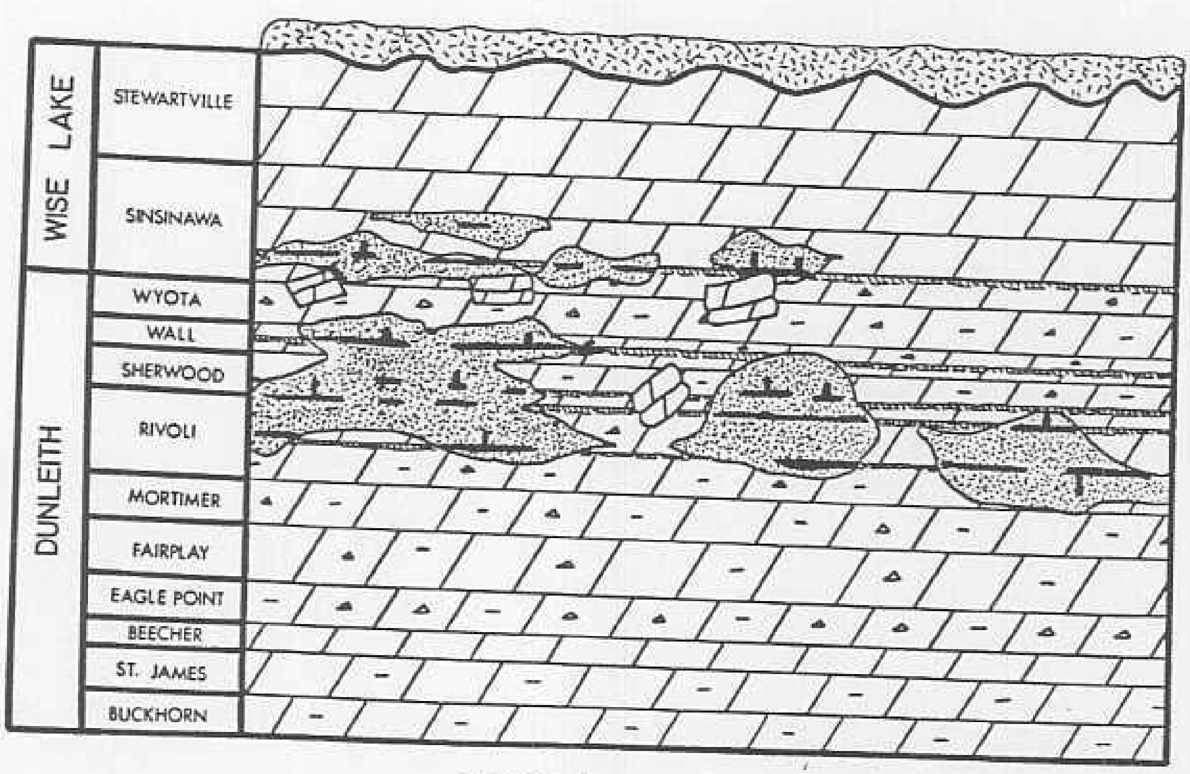
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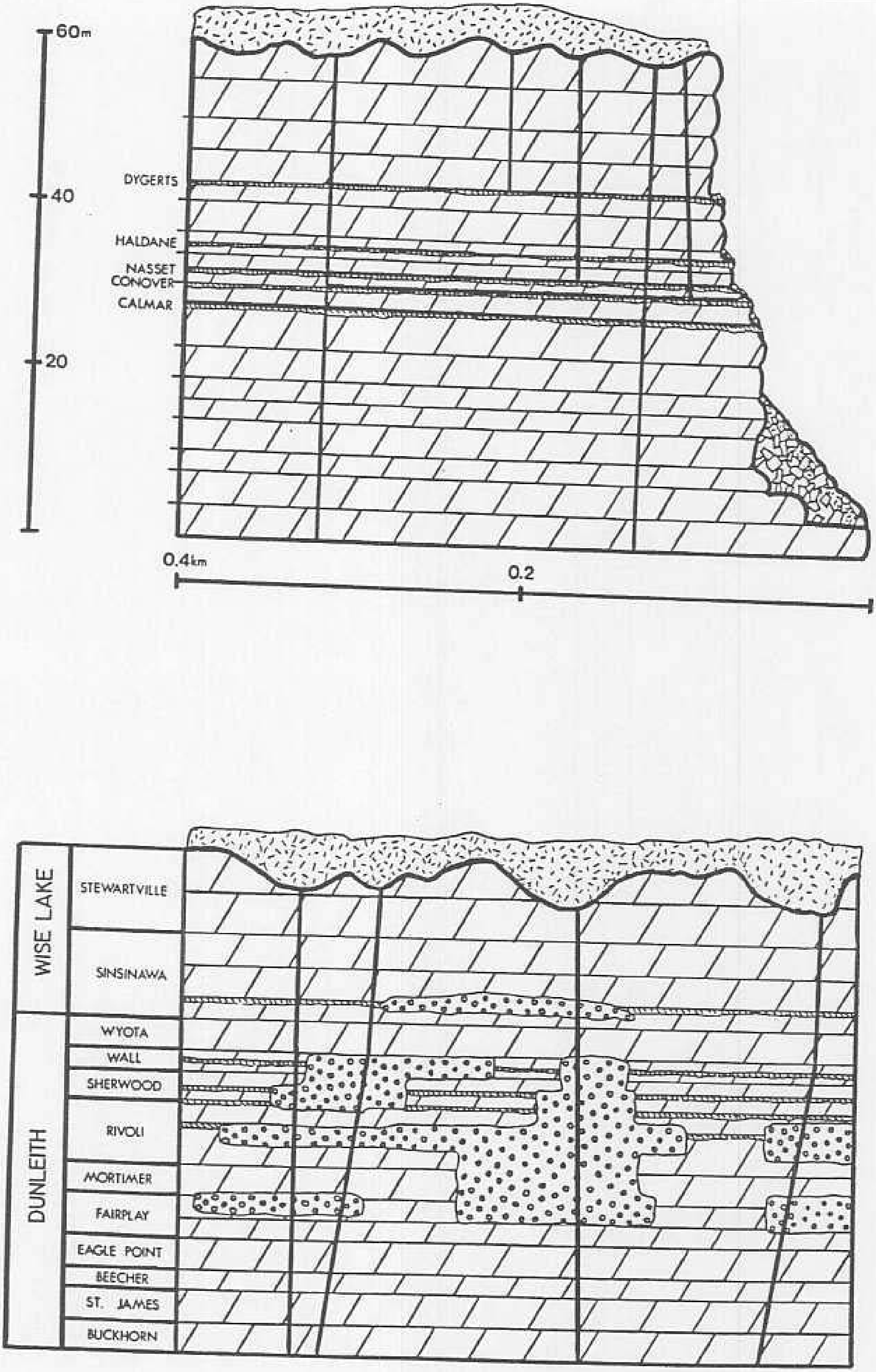
STEWARTVILLE
SINSINAWA
WYOTA
WALL
SHERWOOD
RIVOLI
MORTIMER
FAIRPLAY
EAGLE POINT
BEECHER
ST. JAMES
BUCKHORN

FIGURE 1.

FIGURE 2. Cross section (upper) and edge-on outside (lower) views of maderate cliff. Stratigraphy and bentonite terminology as in last figure. Note rather subdued sinks, internal fissure system consisting only of a few major essentially vertical narrow joints (black), some penetrating and others terminating on bentonites and associated narrow fissures, which serve as horizontal water conduits. Ice storage capacity is much less than in algific slopes (upper). Maderate patches (lower) form along or near horizontal fissures (generally bentonites but occasionally shaly bedding planes) exposed on cliff face.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MORTIMER
FAIRPLAY
EAGLE POINT
BEECHER
ST. JAMES
BUCKHORN

FIGURE 2.

TABLE 1. POPULATION RANKINGS FOR MADERATE CLIFF PLANTS

SPECIES	SITE	POPULATION	RANK
Sedum integrifolium leedyi	MN19 Deer creek 1	1,500-2,000	(1)
	MN33 Simpson	1,500	(2)
	MN38 Bear Creek	1,500	(3)
Draba arabisans	MN33 Simpson	2,500	(1)
	MN19 Deer Creek	2,000	(2)
	MN38 Bear Creek	1,500	(3)
	MN36 Deer Creek 3	250	(4)
	MN32 Deer Creek 2	200	(5)
	MN35 Maple Valley Golf Course	100	(6)

TABLE 2. POPULATION RANKINGS FOR MADERATE CLIFF SUCCINEIDS

SPECIES	SITE	POPULATION	RANK
Succinea n.sp. morph 1	MN41 Root River 4	very large	(1)
	MN40 Canfield Creek 10	very large	(2)
	MN33 Simpson	very large	(3)
	MN38 Bear Creek	large	(4)
	MN19 Deer Creek 1	medium	(5)
	MN36 Deer Creek 3	small	(6)
	MN32 Deer Creek 2	small	(7)
	MN34 Simpson East	small	(8)
	MN35 Maple Valley Golf Course	very small	(9)
Succinea n.sp. morph 2	MN40 Canfield Creek 10	very small	(1)
	MN38 Bear Creek	very small	(2)
	MN33 Simpson	very small	(3)
	MN36 Deer Creek 3	very small	(4)
	MN34 Simpson East	very small	(5)

TABLE 3. RANKINGS FOR MADERATE CLIFFS OF MINNESOTA

RANK	SITE	FAUNAL DIVERSITY	FLORAL DIVERSITY	SIZE
1	MN41 Root River 4	high	medium	very large
2	MN33 Simpson	high	high	very large
3	MN40 Canfield Creek 10	high	medium	large
4	MN19 Deer Creek 1	medium	high	medium
5	MN38 Bear Creek	medium	high	large
6	MN36 Deer Creek 3	medium	low	medium
7	MN32 Deer Creek 2	medium	low	medium
8	MN34 Simpson East	low	low	small
9	MN35 Maple Valley Golf Course	low	low	medium

APPENDIX 2. FLORA AND FAUNA

(Numbers in parentheses are field designations)

FILLMORE COUNTY.

1. (MN2) Spring Valley Creek 2. Extensive and rich complex, basically bilevelled Dunleith-Wise Lake algific site, strongly perched for ½ its length. No signs of disturbance. Snails not completely picked. Length extended to triple that previously known.

Chrysosplenium ioense
Adoxa moschatellina
Rhamnus alnifolia
Cerastium arvense
Cornus canadensis

Vertigo hubrichti
Discus catskillensis
Hendersonia occulta

2. (MN19) Deer Creek 1. Revisit to site. Snails and plants on wetter W end only, to top of cliff but also onto talus at cliff base. Base subject to pasturing.

Sedum integrifolium leedyi
Draba arabisans

Succinea n.sp. morph 1
Hendersonia occulta

3. (MN32) Deer Creek 2. Very small algific slope (extreme W end) and medium-sized maderate cliff. In pasture, but protected by stream course. Snails mainly at base of cliff.

Draba arabisans

Hendersonia occulta
Succinea n.sp. morph 1

4. (MN36) Deer Creek 3. Small algific slope, very open and exposed, on extreme W end. Medium maderate cliff and moderately wet, not subject to pasturing. Snails mainly on talus at base of cliff and 10' onto face. Litter sample not yet picked.

Adoxa moschatellina
Draba arabisans

Hendersonia occulta
Succinea n.sp. morph 1
Succinea n.sp. morph 2

5. (MN41) Root River 4. Very large and mostly undisturbed maderate cliff and associated algific patches. Subject to pasturing on W 1/3. Snails to 150' above stream level, also in talus and onto surface of algific portions. Probably the best Succinea site.

Hendersonia occulta
Succinea n.sp. morph 1

6. (MN40) Canfield Creek 10. Large and undisturbed maderate cliff with associated spring, cave opening, and colluvial slope (with fossil

OLMSTED COUNTY.

9. (MN33) Simpson. Very large N to nearly W-facing Dunleith-Dubuque maderate cliff, somewhat dry, 140' x 2,300'. SE$\frac{1}{4}$NW$\frac{1}{4}$SE$\frac{1}{4}$ and NW$\frac{1}{4}$NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 20, T105N R12W, Pleasant Grove Twp., Simpson quadrangle.

10. (MN 34) Simpson East. Small (100' x 400') very dry maderate cliff, upper Dunelith-Wise Lake, NW-facing, along Root River. NE$\frac{1}{4}$NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 16, T105N R13W, Pleasant Grove Twp., Simpson quadrangle.

11. (MN35) Maple Valley Golf Course. NW to nearly W-facing high rocky very dry medium maderate cliff, 160' x 600', across from Golf Course. SW$\frac{1}{4}$SW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 15, T105N R13W, Pleasant Grove Twp., Marion quadrangle. Algific talus slope across tributary on W end of site.

12. (MN37) Table Rock South. Extensive tri-level complex (9 patches) Dunleith-Wise Lake algific slope on W branch of Root River S of Table Rock. 160' x 1400', NW-facing. NE$\frac{1}{4}$NE$\frac{1}{4}$SW$\frac{1}{4}$ and SE$\frac{1}{4}$SE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 11, T105N R13W, Pleasant Grove Twp, Marion quadrangle.

APPENDIX 1. LOCALITIES

(Numbers in parentheses are field designations)

FILLMORE COUNTY.

1. (MN2) Spring Creek 2. Revisit to extensive and complex Rivoli-Sinsinnewa site, extends from SE¼SE¼SE¼ sec. 18 to S½SW¼SW¼ sec. 17 and N½NW¼NW¼NW¼ sec. 20, T103N R12W, Fillmore Twp., Wykoff quadrangle. Slope height to 180' (shallow on W end.), length 1300'.

2. (MN19) Deer Creek 1. Revisit to medium sized (80' x 500') excellent N-facing to NW-facing Wise Lake-Dubuque maderate cliff and associated algific slope on W. end of massive Dunleith-Dubuque cliff on Deer Creek. NW¼NE¼NW¼ sec. 13 and SW¼SE¼SW¼ sec. 12, T103N R13W, Spring Valley Twp., Wykoff quadrangle.

3. (MN32) Deer Creek 2. Very small (20' x 50') N-facing algific slope at extreme W. end of cliff and medium-sized (80' x 500') somewhat dry upper Dunleith-Wise Lake maderate cliff on Deer Creek. N½SW¼SE¼ sec 12, T103N R12W, Spring Valley Twp., Wykoff quadrangle.

4. (MN36) Deer Creek 3. Medium-sized (120' x 500') high Dunleith-Dubuque NW-facing maderate cliff, moderately wet, on meander of Deer Creek. Very small (20' x 70') Dunleith algific slope on W end. NE¼SE¼SE¼ sec 12, T013N R13W, Spring Valley Twp., Wykoff quadrangle.

5. (MN41) Root River 4. Very large and spectacular maderate cliff, 250-300' x 2,600', along Root River. NW¼ and NW¼NE¼ of NW¼ sec. 16, SE¼SW¼ sec. 23, T102N R12W, Forestville Twp., Greenleafton quadrangle. Has excellent algific slope complex (MN16) on W end. Dunleith-Dubuque, N to NW facing.

6. (MN40) Canfield Creek 10. Large and spectacular maderate cliff above Big Spring and Canfield Creek, N to NW-facing, Dunleith-Dubuque, 150' x 1000'. NE¼SW¼SW¼ and NW¼SE¼SW¼ sec. 25, T102N R12W, Forestville Twp., Greenleafton quadrangle.

(MN38) ~~Deer~~ Bear Creek. Large undisturbed, slightly dry N and NW-facing Wise Lake-Dubuque maderate cliff, 140' x 1,200' along Bear Creek. N½SW¼NW¼ sec. 6, ~~T104N~~ T103N R12W, Fillmore Twp., Washington quadrangle.

8. (MN39) Mahood's Creek. Perched Sinsinnewa single-level algific site in several patches on SW side of Mahood's Creek. Ranges from N to nearly W facing. Four main segments, in aggregate 30' x 1100'. NE¼SW¼SE¼ and SW¼ NW¼SE¼ sec. 20, T103N R12W, Fillmore Twp., Wykoff quadrangle.

fauna). Most snails on cliff face and top of talus to 150' above creek level. Algific sites on W end, mostly 200' above creek level (MN10).

Hendersonia occulta
Vertigo hubrichti
Vallonia gracilicosta
Succinea n.sp. morph 1
Succinea n.sp. morph 2

7. (MN38) Bear Creek. Unpastured steep and rocky, somewhat exposed large maderate cliff. Snails sparse on E end, abundant on W: plants with opposite preferences. Most Sedum orange-flowered, deciduous stalks narrow.

Sedum integrifolium leedyi
Draba arabisans

Hendersonia occulta
Succinea n.sp. morph 1
Succinea n.sp. morph 2

8. (MN39) Mahood's Creek. Perched Sinsinnewa algific slope, ranging from very rocky but well-vegetated to open and exposed. Four main patches, all relatively undisturbed.

Mertensia paniculata
Rhamnus alnifolia
Cerastium arvense
Gallium boreale

Hendersonia occulta
Vertigo hubrichti

OLMSTED COUNTY.

9. (MN33) Simpson. Very large maderate cliff, many parts sheer and somewhat dry. Sedum and Draba in most moist areas, especially at top, scattered low down. Snails onto talus and cliff base, mostly to 40' above top of talus. Previously known plant site.

Sedum integrifolium leedyi
Draba arabisans

Hendersonia occulta
Vertigo hubrichti
Vallonia gracilicosta
Succinea n.sp. morph 1
Succinea n.sp. morph 2

10. (MN34) Simpson East. Small, somewhat dry but undamaged site. Draba scattered thinly through full length, Succinea mostly at base of cliff and on talus at E end.

Draba arabisans

Hendersonia occulta
Succinea n.sp. morph 1
Succinea n.sp. morph 2

11. (MN35) Maple Valley Golf Course. Very dry, almost W-facing very exposed and poorly vegetated site. Draba rare and scattered from center to

S end. Succinea only on NE end at base of cliff. No live or recently dead Succinea seen.

Taxus canadensis
Adoxa moschatellina
Cerastium arvense

Draba arabisans

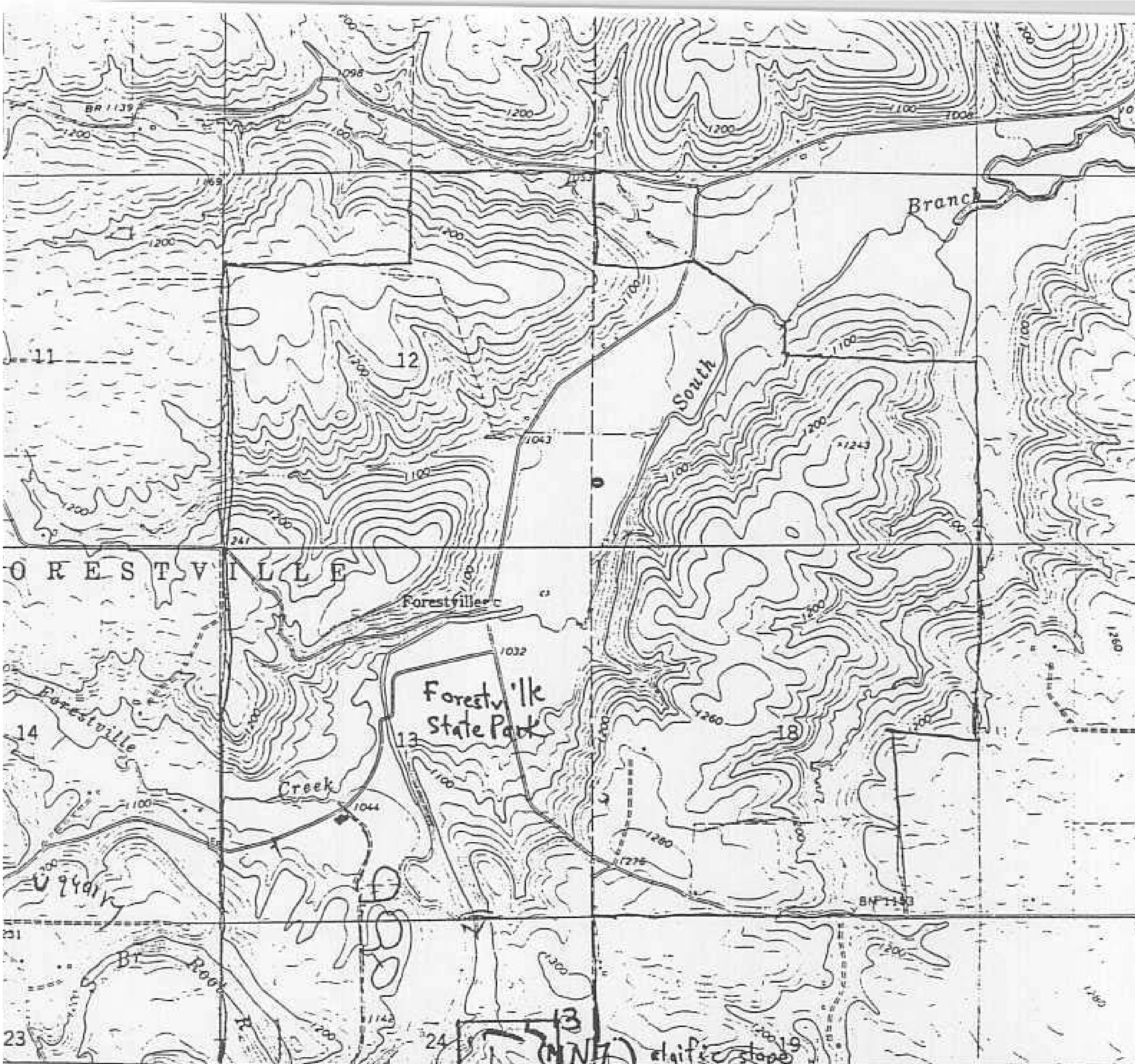
Hendersonia occulta
succinea n.sp. morph 1

12. (MN37) Table Rock South. Large, complex but somewhat diffuse algific slope on Root River. Perfect 3-level site with at least nine patches. Part of NE end used as dump previously. Snails not yet completely picked, and site should be botanized carefully. Northernmost known algific site.

Taxus canadensis
Adoxa moschatellina
Maianthemum canadense
Gallium boreale
Cerastium arvense

Hendersonia occulta

APPENDIX 3. SITE MAPS
(All are portions of USGS $7\frac{1}{2}$'
topographic maps)



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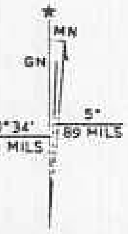

UTM GRID AND 1965 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

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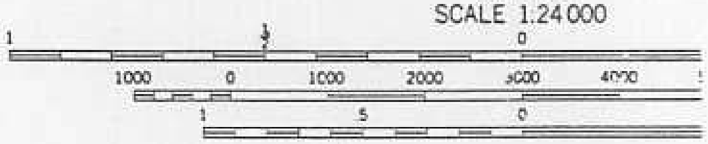

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURA

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A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS

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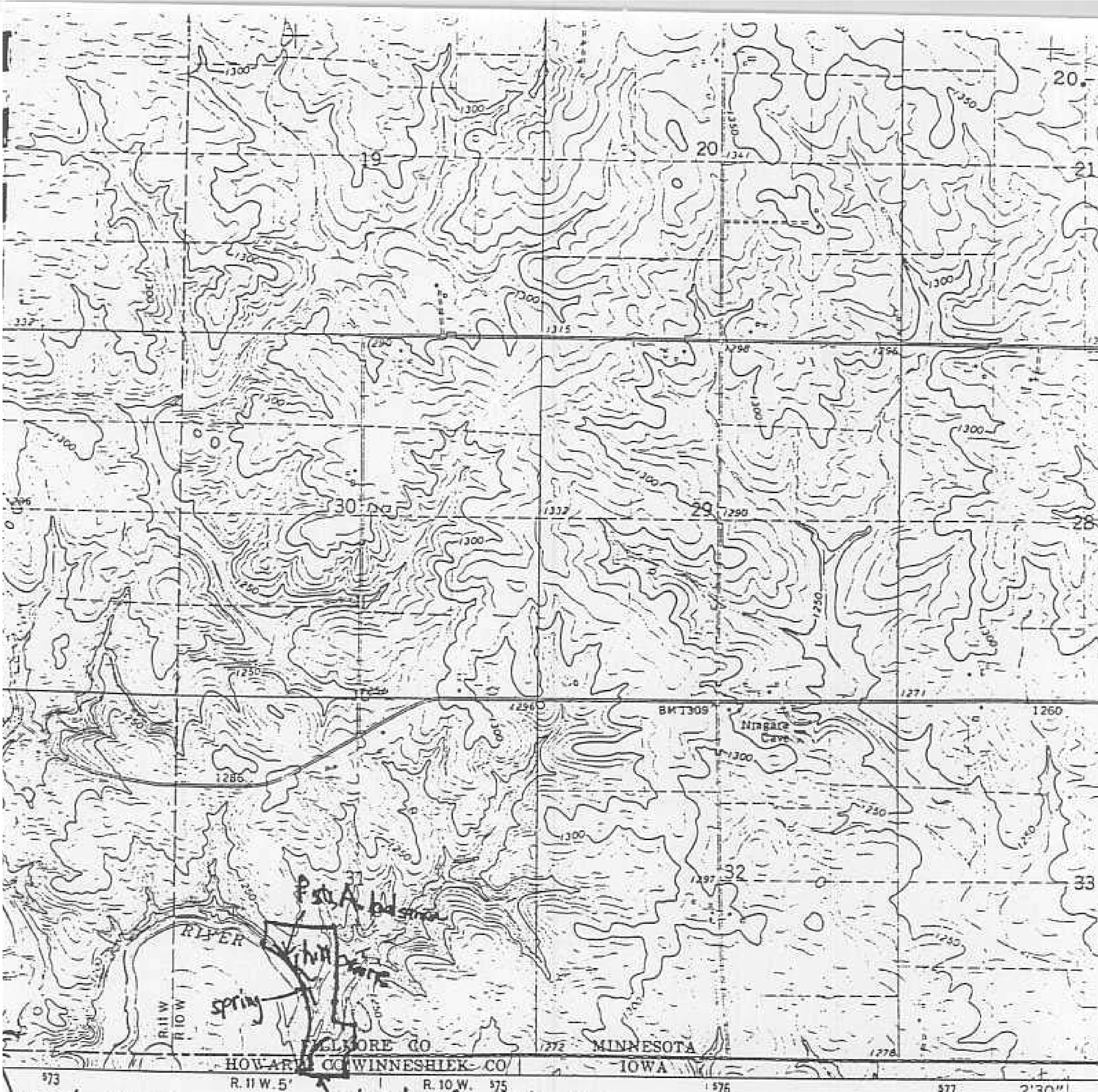


Possible CAS

MNag(22) algific slope

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

MN
GN
0°39'
11 MILS
5°
89 MILS

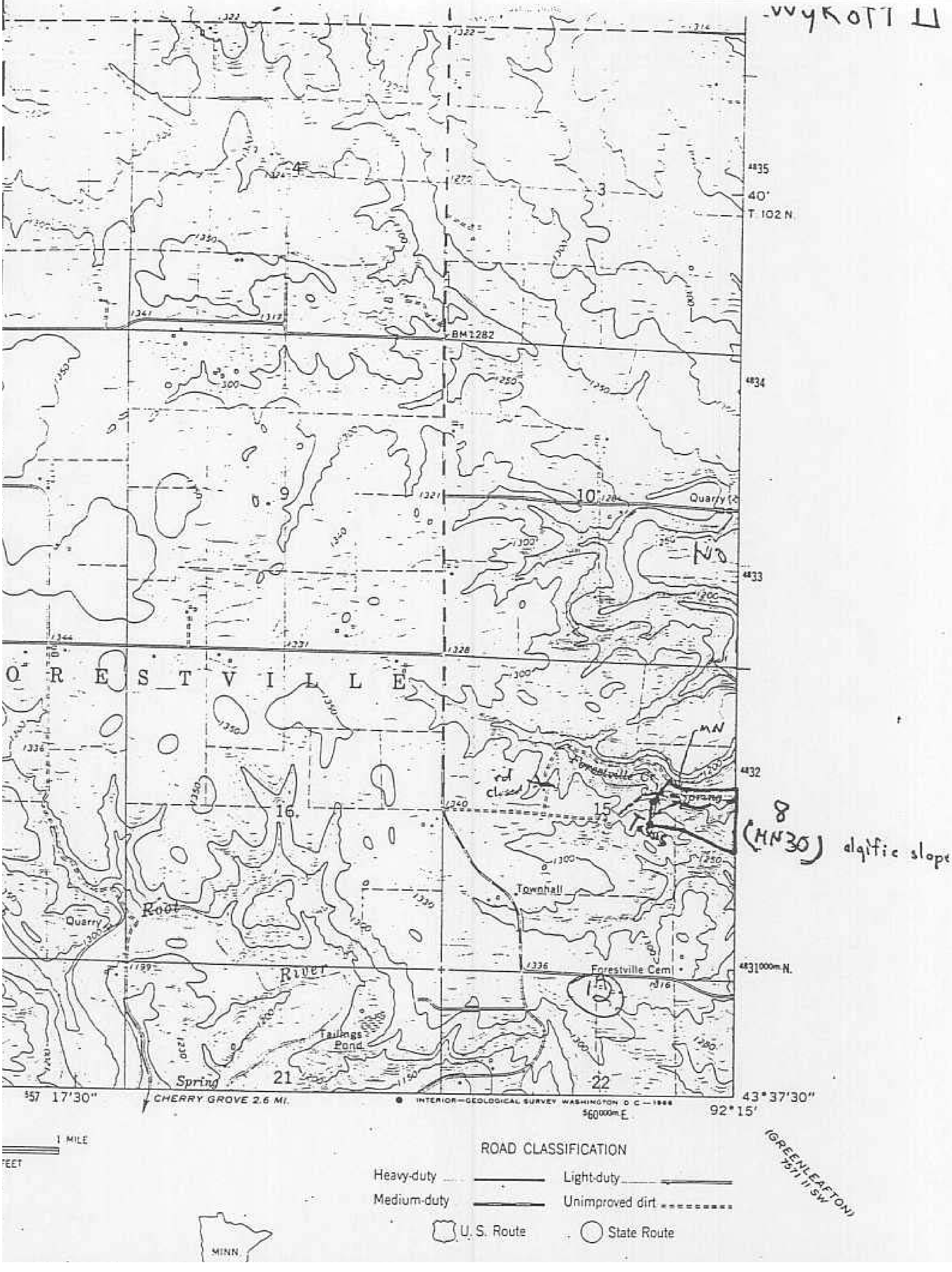
UTM GRID AND 1965 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

zone

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D. C. 20242
AND BY THE IOWA GEOLOGICAL SURVEY, IOWA CITY, IOWA 52240
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

Harmony II

WYKOFF II



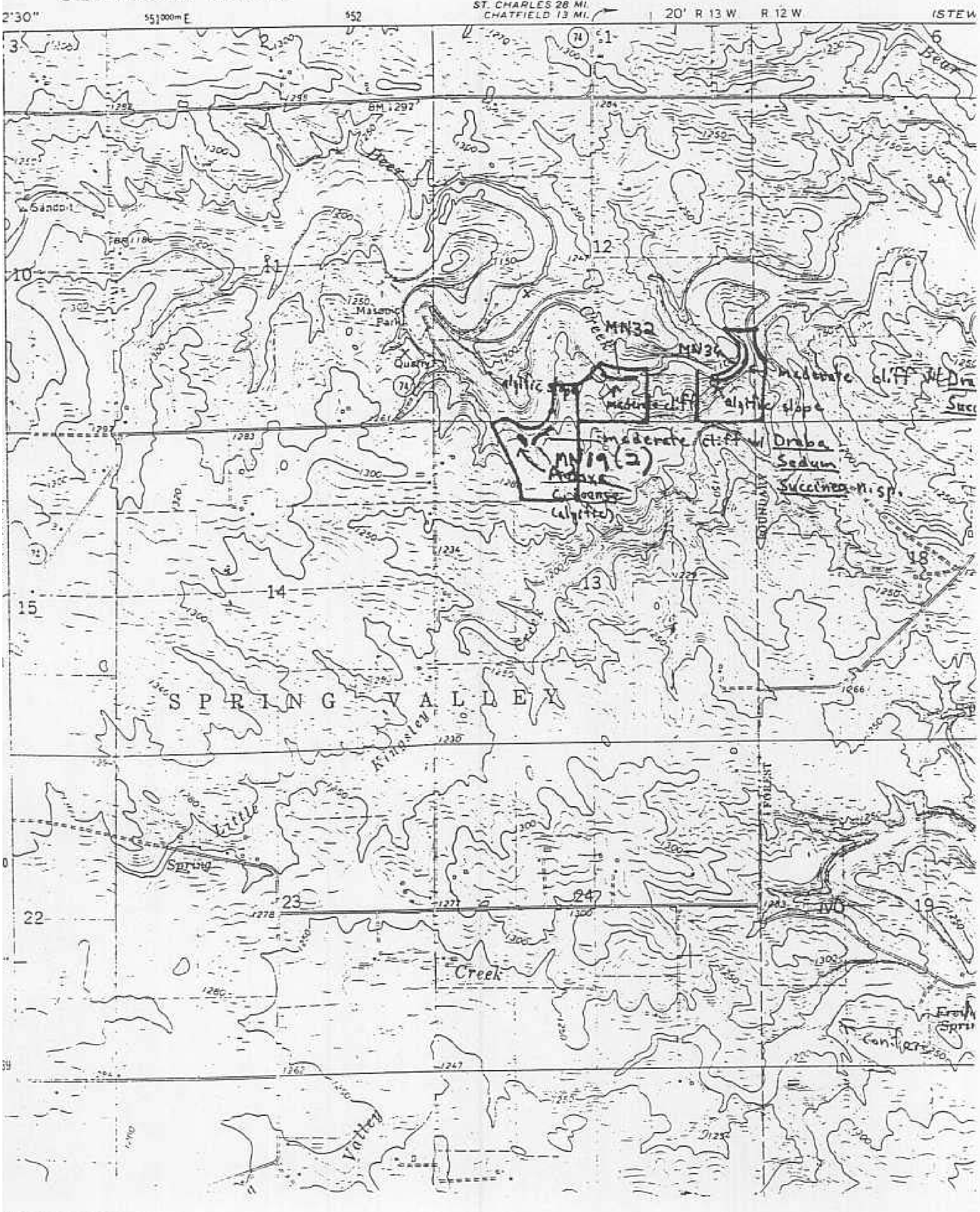
4835
40'
T. 102 N.
3
4
BM1282
4834
10
Quarry
9
ND
4833
O R E S T V I L L E
MN
4832
Forestville Cr.
rd closed
Spring
Talus
16
15
8
(MN30)
algific slope
Townhall
Quarry
Root
River
4831000m N.
Forestville Cem
Tailings Pond
Spring
21
22
557 17'30"
CHERRY GROVE 2.6 MI.
INTERIOR—GEOLOGICAL SURVEY WASHINGTON D C—1966
560000m E.
43°37'30"
92°15'
(GREENLEAFTON)
7571 II SW
1 MILE
FEET
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U. S. Route
State Route
MINN


Deer
Creek
Curtis
Creek
Creek
(MN5) algific slope
18
17
16
Spring
Valley
FILLMORE
algific slope
algific slope
algific slopes
19
20
21
Park
St Johns Cem
30
29
28
MINNESOTA MEMORIAL HARD

Wykoff ☐

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE
DEPARTMEN



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