An investigation of the influence of the Michigan Avenue road extension on water distribution and availability on the Schmeckle Reserve, Stevens Point

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Abstract

Vegetation cover maps of the Schmeckle Reserve, Stevens Point, from 1976 and 1995 were used in an attempt to determine whether a road (Michigan Avenue extension) built in the mid 1970's had subsequently had a dramatic and persistent influence on the water distribution in the Reserve as was feared. A change in the availability of water to plants would alter the species composition rapidly thereby making it possible to identify regions that have been affected by such a change. Similarly, the change in position and extent of wetland areas was inspected as this is a reliable indication of change in water availability or distribution. The coverages were digitised and overlaid in PC ARC/INFO. There was no indication that the road had significantly influenced water availability at the Schmeckle Reserve. The reliability of the techniques used to draw this conclusion are discussed.

Introduction

The University of Wisconsin - Stevens Point has been purchasing land on its northern border since the early part of this century for the purpose of creating a refuge, now called the Schmeckle Reserve. The land was all privately owned at one time but by the early 1970's most of what is currently the extent of Schmeckle had either been purchased by, or donated to, the University. At about that time Sentry Insurance purchased land to the north of Schmeckle with the intent of constructing a large office building to house their base of operations in the northern United States. For this project they required a large amount of sand and a deal was struck between the contractors and the University: the contractors could mine sand from Schmeckle if they constructed an artificial lake in the process of doing so.

The temporary road they created for their mining vehicles is what is now the portion of Michigan Avenue that snakes through Schmeckle. The City of Stevens Point decided that the mining road was more strategically located with regard to transportation and they subsequently negotiated with the University to be allowed to make the road permanent. It was agreed that the road could be paved with two conditions: (1) that Reserve Street (a street which ran parallel to Michigan Avenue through Schmeckle) would be completely removed; (2) that the new stretch of Michigan Avenue would contain numerous culverts to facilitate the passage of water from the west side of the road to the east side. [It was believed that the flow of water through the region occurred from the north-west to the south-east.]

The contractors fulfilled the first condition but failed to satisfactorily fulfill the second. They put far fewer culverts into the road than they originally had promised and it was feared by the University that this would have a detrimental affect on water distribution on the Reserve.

In 1976, soon after the road was constructed (construction was completed around 1974 / 1975), a biologist[1] and a botanist[2] from UWSP created a vegetation cover map of Schmeckle. Nineteen years later (1995) a graduate student[3] created another vegetation cover map of Schmeckle. The purpose of this study is to investigate whether there is any evidence that the construction of the road had a dramatic and long-lasting influence on the water distribution of the area as indicated by changes in the vegetation cover and extent of wetland areas. This was accomplished using the aforementioned maps as the method below describes.

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[1] Dr. David Hillier
[2] Dr. Robert Freckman
[3] Robert Chastain

Methods

1. Data from 1976 originates from a survey conducted by Drs David Hillier and Robert Freckman (UWSP). Vegetation cover types were mapped for the extent of the Reserve at that time. The Reserve was considerably smaller than it is presently as the land was gradually bought by the University as private owners vacated. A photocopied portion of the hand-drawn map they produced is shown in Figure 1. This map was digitized in ARC/INFO ver. 3.3. (refer to Figure 2).

2. Data from 1995 originates from aerial photographs taken in April, 1993, that were interpreted in conjunction with field surveys by Bob Chastain (UWSP graduate student). Vegetation cover types were drawn onto an acetate sheet placed on the photograph which was in turn photocopied and digitized in ARC/INFO ver. 3.4D. Figure 3 is a black and white photocopy of the original color air photograph, Figure 4 displays the digitised version of Chastains vegetation mapping.

3. The coverages were CLEANED and BUILDed as necessary, and i.d. points were added to each of the polygons. The 1976 coverage was converted to ver. 3.4D using the INFODB CONVERT INFO command.

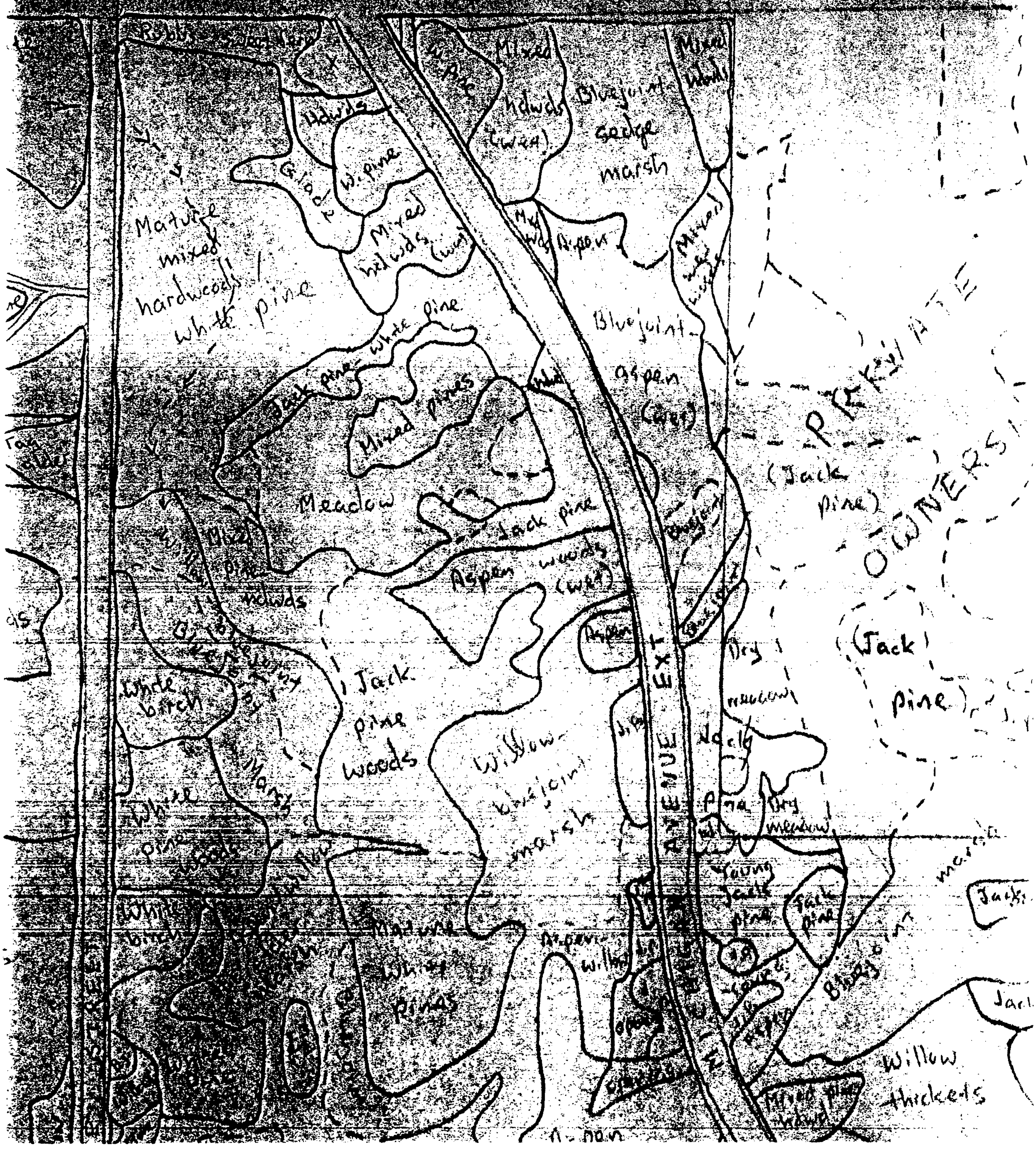
4. Using TABLES, databases for each of the cover maps were constructed. Classification of the vegetation was based on B. Chastains fifteen point cover type description summarized as follows:

Cover type	*Description*	*Number code*
1	Oak barrens	1
2a	Jack and White pine barrens	2
2b	Jack pine barrens	21
3a	Birch, Maple, Oak deciduous type	31
3b	Maple, Birch, Rock and Pothole type	32
4	Aspen, Birch	4
5	Heavily disturbed areas / developed	5
6	Aspen, Fern type	6
7	Wetlands	7
8a	Young White pine type	81
8b	Young and Old Mixed pine type	82
9	Meadow and Prairie type	9
10a	Mixed canopy old growth	10
10b	White pine dominated canopy old growth	101
10c	Logged old growth	102

Descriptions provided by B. Chastain of each of these categories were used to classify the vegetation cover from 1976 such that the two databases were compatible. Printouts of the two .PAT files are shown in Appendix I.

5. As the maps from 1976 and 1995 were not of the same scale it was necessary to transform the 1995 coverage scale to that of the 1976 coverage. The two coverages shared only four tic marks (each of the originals has six tic marks) thus the two uncommon tics from each coverage were first deleted using the DELETETIC command.

6. The transformation procedure requires first that a new, empty coverage be created (CREATE command) and the .bnd and .tic files from the 1976 coverage be copied into the empty coverage (copied using DOS commands). The TRANSFORM command subsequently converted the 1995 coverage using the tic information in the empty coverage. The RMS error of the transformation was acceptable (input, output: 0.0394, 0.0974) as shown in Table 1. (Following transformation and upon inspection of the .bnd and .tic files in each of the coverages, it was necessary to manually change the .bnd co-ordinates of the transformed coverage in TABLES so that the two matched exactly. If the boundaries were slightly



Preliminary
Mature mixed hardwoods / white pine
Glade
W. pine
Hdwds
Mixed hdwds (wet)
Mixed hdwds (wet)
Bluejoint sedge marsh
Mixed hdwds
Bluejoint aspen (wet)
Jack pine white pine
Mixed pines
Meadow
Jack pine
Aspen woods (wet)
Aspen
Mixed pine hdwds
White birch
Jack pine woods
Willow bluejoint marsh
White pine woods
Mature white pines
Dry meadow
Jack pine
Young Jack pine
Willow thickets
Mixed pine hdwds
AVENUE EXT
PRIVATE OWNERS
(Jack pine)
(Jack pine)

Figure 3. A black and white photocopy of the color air photograph used by Chastain to map vegetation cover types. (North is to the right of this page). Note the Sentry Insurance building is just visable in the upper right hand corner of the page. The winding road is Michigan Avenue (the former Sentry mining road) and the remains of Reserve Street are clearly distinguishable, as is the artificial lake. The Headquarters Building, also mentioned in the Introduction section, is highlighted.

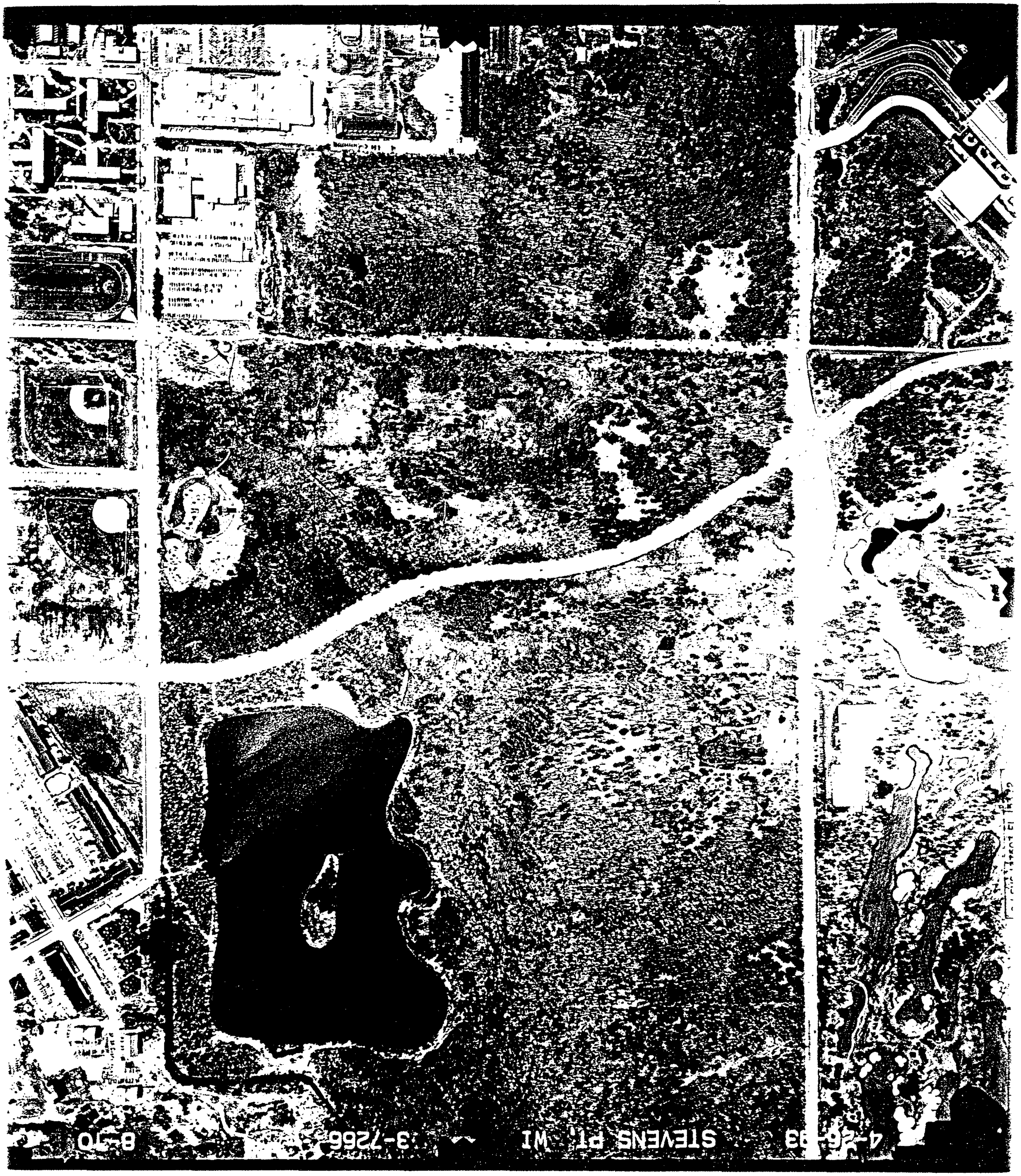
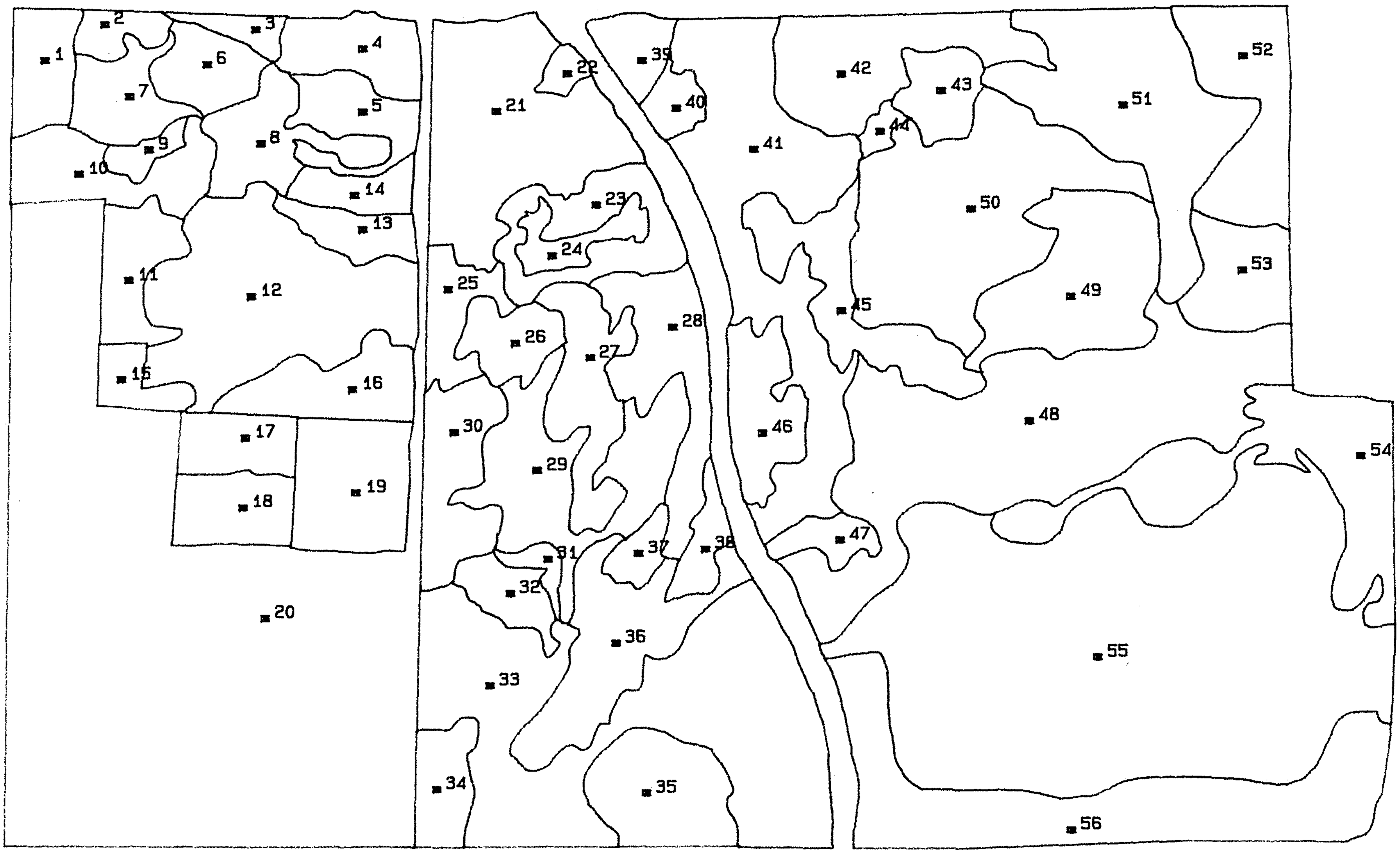


Figure 4. A digitised version of a vegetation cover map produced by B. Chastain in 1995. Refer to Appendix I for information relating to the contents of each of the polygons. The numbers represent label identification numbers.



different it appeared that the two coverages would not overlay precisely in ARCPLOT. This was not an absolutely necessary step in the procedure.)

Table 1. Transformation statistics:

Scale (x,y) = (2.419129, 2.530430)
Translation = (12.31742, -4.654748)
Rotation (degrees) = (0.5148900)
RMS Error (input, output) = (0.03936737, 0.09742557)
Transformation matrix (A, B, C) = (2.419031, -0.02173927, 12.31742)
(D, E, F) = (0.002754663, 2.530429, -4.654748)

Tic ID	Input x Output x	Input x Output x	x Error	y Error
1	6.50900	3.28700	0.02743	-0.1330
	27.9640	3.69400		
2	3.78000	3.30900	-0.02858	0.01385
	21.4180	3.71500		
3	3.88200	8.45400	0.1213	-0.05881
	21.4030	16.8070		
4	4.50600	8.49800	-0.1202	0.05825
	23.1530	16.8030		

7. Some neighboring polygons had identical vegetation codes. The DISSOLVE command simplified each of the coverages by removing borders between polygons with similar codes thereby reducing the overall number of polygons. (In particular, the 1976 coverage was reduced from 122 to 91 polygons and the 1995 coverage from 57 to 42 polygons.)

8. The IDENTITY command was used to combine the two coverages. 388 polygons were generated in the output coverage (*IDENTVC*). [IDENTITY computes the geometric intersection of the two coverages; feature attributes from both coverages are joined in the output coverage.]

9. Each of the polygons in *IDENTVC* has two numbers associated with it that represent the vegetation cover type in 1976 and again in 1995. By inspection of these numbers it is thus possible to determine how the vegetation cover has changed in the intervening 19 years. For each of the 388 polygons, it was determined which of four categories the change fell into: (1) no change whatsoever; (2) a moderate or gradual change that would be expected to occur from natural successional processes; (3) a dramatic change that is unlikely to have occurred naturally; (4) the change could not be assessed due to data lacking from 1976 as a result of the Reserve being smaller historically than it is at present. The second part of the analysis involved inspecting the differences in the two numbers to determine whether an area had (1) become wetland, (2) remained wetland or (3) ceased to be wetland. ADDITEM was used to add appropriate numeric columns to the .PAT file and each of the polygons was encoded with the numbers as described above.

10. After classifying the polygons into each of the two categories (i.e. changes in vegetation cover and changes in wetland areas) the DISSOLVE command was used once more to simplify the coverages.

11. Two map compositions were created in ARCPLOT to display the results of the analysis (see Figures 5 and 6).

Summary of commands used:

ADS		NOTES: Snap distance was set to 0.05; weed tolerance was set to 0.001. Coverages digitised using six tic marks.
CLEAN		SYNTAX: CLEAN COV1 COV2 0.1 0.004
BUILD		
TABLES	SELECT COV.PAT UPDATE LIST ADDITEM DROPITEM	
DELETETIC		SYNTAX: DELETETIC COV
CREATE		SYNTAX: CREATE COVNAME
TRANSFORM		SYNTAX: TRANSFORM INCOV OUTCOV
DISSOLVE		SYNTAX: DISSOLVE INCOV OUTCOV .PAT-ITEM
IDENTITY		SYNTAX: INCOV IDENTITY-COV OUTCOV POLY
ARCPLOT	DISPLAY 4 MAP PROD.MAP MAPEXTENT COV PAGESIZE 17 11 SHADESET HP7475.SHD ARCS COV RESELECT COV POLYS CC = # POLYGONNSHADES COV # CLEARSELECT TEXTFONT # TEXTSIZE # # (eg 0.12 0.9) DISPLAY 1 PLOT PROD.MAP	BOX * MFRESH MAPLIMITS * MAPEXTENT A:NARROW ARCS A:NARROW MOVE * MMOVE * MFIT * MSELECT # # #.. MGROUP TEXT '---'

Results

If the construction of Michigan Avenue had caused a severe change in the flow of water across the Schmeckle Reserve then one would expect to see dramatic changes in the vegetation cover and extent of wetland areas in the locality of the road. This does not appear to be the case. As Figure 6 displays, there are areas in which the vegetation has changed dramatically (shaded red regions) but for the most part these areas are not near Michigan Avenue. Small patches of highly changed areas are present but I would submit that they are more likely the result of inaccuracies in the mapping of the vegetation types than they are a true reflection of change. If Michigan Avenue had significantly influenced the distribution of water then the largest areas of highly changed land would be near the road.

The same can be said for the distribution of wetland areas (refer to Figure 6) which do not appear to have changed significantly in the years since the development of the road. Once again, allowances must be made for inaccuracies in the mapping of wetland areas (i.e. the map must not be taken too literally). It appears that areas that were wetlands in 1976 are generally still wetland and that the overall trend shows a slight increase in the extent of wetland areas on Schmeckle.

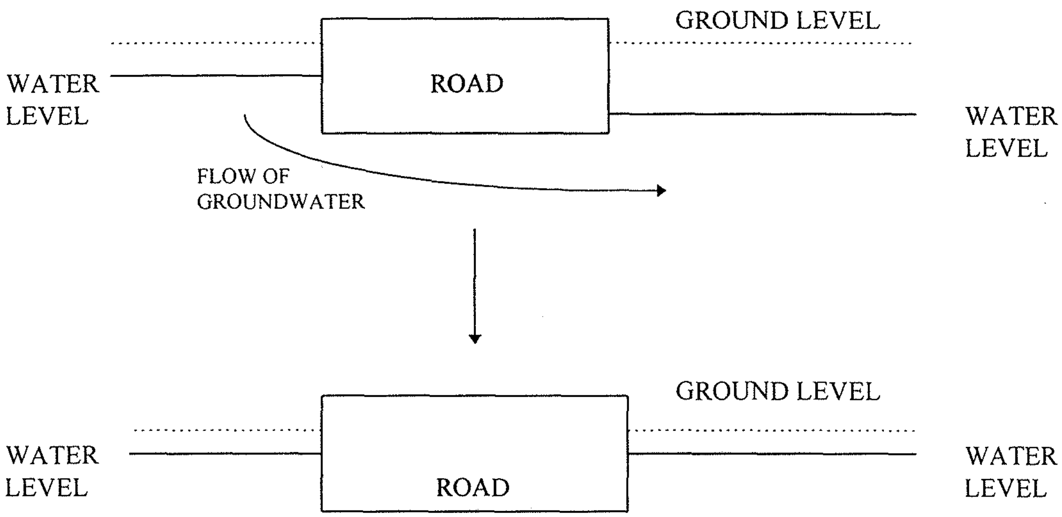
The two areas on the 'Vegetation Cover Changes' map (Figure 5) that do appear to signify a significant change in vegetation cover are the two largest red-shaded regions. It is interesting to note that they both occur in areas where development has taken place. In particular, the block on the west side of Schmeckle is adjacent to a very large paved area (several adjoining large parking lots) and the block at the north end of Schmeckle contains the building and parking lot of the Schmeckle Reserve Headquarters. The development of both of these areas has occurred in the intervening period between vegetation assessments.

It is also interesting to note that there are few areas of dramatic change in the vicinity of the lake. It was speculated that the lake would act as a water sink, decreasing the availability of water nearby. Had this been the case then one would expect to observe drastic changes in vegetation cover (moisture loving species like willow would be replaced by desiccation tolerant species like grasses). This does not appear to have occurred.

Discussion

The deficiency of culverts in the roadbed of Michigan Avenue through Schmeckle does not appear to have significantly influenced the flow / distribution of water. One would expect that the road would indeed affect the flow of surface water in the roads' immediate vicinity though this influence does not seem to affect the overall availability of water. In other words, the influence of the road is either so small that it is insignificant or the influence is compensated for by the myriad of other factors that affect water distribution in the area.

For instance, the water table on Schmeckle is very close to ground level in many areas (as documented by B. Chastain) thereby ensuring that water is available to vegetation regardless of whether the vegetation receives water via surface runoff. Any deficiency in surface runoff water could also be compensated for by the flow of ground water beneath the road as illustrated below.



In addition to this, very little surface runoff exists in areas in which the soil is covered by vegetation types that deposit a layer of humus on the soil surface. In such areas the ground level vegetation (e.g. mosses, lichens, grasses, etc) and the top few inches of soil have a sponge effect thereby limiting not only the flow of surface water but also the availability of water that can flow.

However, given the inaccuracies in the original data and in the method employed to analyse the data, I do not feel I can draw these conclusions with a reasonable degree of certainty. The analysis was rudimentary at best. In particular, I am at odds with pigeonholing the various vegetation types into the fifteen categories mentioned in the Methods section. Attempting to conform the cover map from 1976 to the same format as the 1995 cover map proved to be a very subjective exercise. Areas were often labeled so simply that they could have fallen into several of the categories Chastain used. The most condemning fault with the data from 1995 was that the scale of classification was too broad (i.e. Chastain used an aerial photograph to identify large sections of land that was pigeonholed as a single vegetation cover type.) Undoubtedly there is considerable variation within each of those sections and a finer resolution to his classification would have improved the reliability of this study.

It is not uncommon to have to deal with such problems. This study represents an attempt to test a hypothesis using data that was not collected for the purpose of such an analysis. The information available to a researcher is never perfect thereby necessitating making the most of that which is available. The question then becomes 'is it *reasonable* to use the available information in a certain way to test particular hypotheses and draw particular conclusions?' With regard to this study it is only reasonable to view this study as a cursory investigation. I found no evidence of widespread dramatic changes occurring as a result of the construction of the road. I did not look at the specifics of how the vegetation changed over time, only that it changed or it did not. It may well be that the road has significantly influenced species composition or the distribution of rare or sensitive species on Schmeckle but it was not within the scope of this project to investigate such ideas.

Nor was it in the scope of this project to attempt to identify the causes of dramatic change in the two large red-shaded regions on Figure 5 (one to the west, one to the north). One might speculate that the development that has occurred within or adjacent to each of them has been the ultimate cause of the change but the mechanism by which such a change might occur can only be guessed. For instance, the region on the west side that borders a vast parking lot might be influenced by the runoff from the lot that is polluted with vehicle emissions (oils, gas, etc) and eroded substances from the paving surface (tar, acidic compounds from concrete, etc). The region to the north that contains the relatively new visitors center and parking lot may be influenced by the high occurrence of trampling. Visitors to the reserve are concentrated around the visitors center and much landscaping / mowing has taken place in that region. While both of these causal descriptions may sound feasible or even likely, clearly a focused investigation of such ideas is required.

With regard to the period of elapsed time between the vegetation surveys, one must question whether nineteen years is a sufficient period of time for the vegetation to have changed as a result of road building. I believe it is a more than adequate time for effects to manifest themselves. More often than not vegetation does change relatively slowly and succession is a gradual process but nineteen years is plenty of time in which observable changes would be expected to occur. In fact, it is a long enough period of time that one might *expect* to see moderate changes in vegetation cover. Areas that have not changed at all in that period of time are almost as remarkable and indicative of a problem as areas that have changed dramatically. A glance at Figure 5 will show that there are large tracts of land around the Michigan Avenue extension that have remained the same (the blue-shaded regions). It would be a worthy investigation to look more closely at exactly how much these areas have remained unchanged and whether such a consistency is linked to the road. One might be astonished to find that the road is actually serving to maintain the vegetation cover in Schmeckle by preventing succession (though I would not even dream of speculating a causal pathway by which this might occur).

Acknowledgments

I would like to express thanks to Bob Chastain for his co-operation and willingness to make materials available to me. All the work regarding the identification and classification of cover types on the Schmeckle Reserve in 1995 is his and his alone.

Appendix I. The .PAT printout below refers to the vegetation cover map from 1976 (see Figure 2.) The numbers in the polygons in Fig. 2 correspond to the numbers in the penultimate column of this table. The values in the final column correspond to cover types as described in section 4 of the Methods.

Record	AREA	PERIMETER	VEG76C3#	VEG76C3-ID	COV
1	-310.294	128.862	1	0	0
2	1.514	6.216	2	118	9
3	1.968	6.520	3	117	9
4	3.611	9.118	4	116	4
5	2.672	8.237	5	115	4
6	2.080	6.341	6	114	1
7	18.452	31.974	7	91	4
8	0.722	4.754	8	92	1
9	0.575	3.105	9	93	1
10	18.274	38.107	10	68	1
11	0.471	3.228	11	65	3
12	1.821	6.107	12	64	7
13	0.895	4.495	13	63	32
14	0.489	3.138	14	62	101
15	2.097	7.022	15	1	101
16	0.237	2.094	16	60	10
17	0.535	4.492	17	61	10
18	2.783	7.988	18	4	81
19	0.609	3.795	19	5	32
20	2.289	6.754	20	6	101
21	4.937	11.972	21	120	10
22	20.187	30.189	22	112	1
23	1.908	6.525	23	3	81

Continue?

24	0.217	2.396	24	59	3
25	0.406	4.020	25	58	9
26	0.423	2.564	26	57	2
27	3.050	9.344	27	7	9
28	0.944	4.147	28	2	9
29	4.466	19.783	29	119	21
30	0.649	3.639	30	56	4
31	0.114	1.692	31	66	4
32	1.965	9.426	32	67	7
33	1.810	5.476	33	8	3
34	6.255	28.346	34	46	2
35	4.035	9.499	35	9	2
36	0.155	1.772	36	10	2
37	0.115	1.393	37	113	2
38	2.453	11.623	38	53	9
39	14.492	22.881	39	15	101
40	0.657	3.786	40	54	2
41	0.077	1.312	41	55	3
42	4.150	8.487	42	90	1
43	0.738	5.692	43	11	2
44	8.279	21.005	44	18	2
45	1.240	4.751	45	69	21
46	0.181	2.061	46	70	7
47	2.049	7.936	47	45	7

Continue?

48	0.909	5.523	48	52	10
49	0.311	2.073	49	12	101
50	0.182	2.471	50	71	9
51	10.167	25.154	51	111	21
52	1.048	6.412	52	51	4
53	0.584	3.963	53	72	9
54	1.001	3.825	54	14	3
55	0.927	7.379	55	73	21
56	0.683	4.060	56	44	3

58	20.388	57.282	58	[illegible]	7
59	0.203	1.676	59	50	4
60	0.371	2.301	60	13	9
61	4.265	14.155	61	108	2
62	1.279	12.591	62	121	7
63	12.946	22.579	63	86	11
64	0.123	1.648	64	89	21
65	0.287	2.614	65	49	21
66	0.076	1.414	66	43	10
67	1.217	4.582	67	42	10
68	0.057	0.887	68	74	9
69	0.308	2.530	69	75	9
70	3.929	10.435	70	16	32
71	1.305	6.638	71	41	7

Continue?

72	0.666	4.227	72	76	21
73	4.120	10.448	73	17	81
74	15.421	35.275	74	19	10
75	0.257	2.013	75	78	21
76	0.341	3.503	76	48	21
77	0.190	2.066	77	85	21
78	0.445	2.791	78	40	3
79	0.336	3.737	79	109	3
80	1.064	5.824	80	39	101
81	0.251	3.347	81	110	101
82	27.267	22.521	82	104	0
83	0.471	4.947	83	80	4
84	0.066	0.941	84	77	21
85	1.986	8.431	85	35	4
86	0.361	3.477	86	47	9
87	0.672	7.163	87	87	21
88	1.634	7.404	88	81	11
89	0.097	1.553	89	79	2
90	0.317	2.620	90	107	101
91	1.432	6.932	91	106	2
92	0.057	0.984	92	38	7
93	0.158	1.818	93	37	11
94	0.504	3.625	94	22	7
95	1.392	5.465	95	20	32

Continue?

96	0.354	2.411	96	82	10
97	0.975	4.802	97	34	11
98	0.162	1.736	98	36	101
99	2.046	8.712	99	94	11
100	0.186	1.833	100	21	7
101	0.472	3.117	101	84	21
102	0.982	4.466	102	105	3
103	0.394	2.566	103	83	11
104	16.846	20.697	104	23	5
105	0.350	2.361	105	32	11
106	0.696	3.252	106	31	4
107	2.341	8.388	107	103	9
108	0.368	2.877	108	26	4
109	0.492	2.952	109	29	4
110	0.945	5.599	110	33	4
111	0.581	4.600	111	27	9
112	3.289	7.345	112	30	5
113	0.337	2.460	113	95	5
114	0.085	1.095	114	28	4
115	0.945	3.925	115	24	5
116	0.526	4.230	116	98	11
117	0.693	5.063	117	99	4
118	2.335	3.172	118	96	11
119	0.501	5.122	119	100	4

Continue?

121	0.668	3.949	121	101	21
122	0.842	6.068	122	97	4

Enter command:

Appendix I (cont.) The .PAT printout below refers to the vegetation cover map from 1995 (see Fig. 4). The numbers in the polygons in Fig. 4 correspond to the numbers in the penultimate column of this table. The values in the final column correspond to cover types as described in section 4 of the Methods.

RECNO	AREA	PERIMETER	COV95C2_	COV95C2_ID	COV
1	-41.3697	48.3183	1	0	0
2	0.6756	4.5194	2	52	1
3	1.2798	6.6810	3	51	32
4	0.7451	4.9247	4	42	5
5	0.2924	2.3591	5	1	0
6	0.3490	2.6732	6	4	101
7	1.2445	5.9439	7	21	10
8	0.1395	1.8125	8	2	10
9	0.1947	1.8135	9	39	10
10	0.1012	1.8509	10	3	0
11	1.5984	11.9564	11	41	7
12	0.2799	2.1954	12	6	81
13	0.3243	3.1495	13	7	82
14	0.0681	1.0865	14	22	101
15	0.2500	2.1176	15	43	9
16	0.1273	1.5649	16	40	7
17	0.4241	4.2690	17	8	101
18	0.3236	4.1135	18	5	9
19	1.5661	6.8707	19	50	1
20	0.0574	1.1740	20	44	21
21	0.4668	4.1800	21	10	102
22	0.0925	1.5508	22	9	102
23	0.1891	2.1728	23	14	10

ontinue?

RECNO	AREA	PERIMETER	COV95C2_	COV95C2_ID	COV
24	0.5036	6.8726	24	23	2
25	0.5996	6.2080	25	45	21
26	1.4150	6.3434	26	12	10
27	0.8848	4.6519	27	49	3
28	0.1717	3.1200	28	24	9
29	0.2071	2.3430	29	13	7
30	0.3359	3.1252	30	11	102
31	0.4015	2.7026	31	53	3
32	0.2689	3.4692	32	25	7
33	0.6132	5.9601	33	28	4
34	0.5126	5.2329	34	27	82
35	2.4337	11.2814	35	48	4
36	0.2515	2.3864	36	26	7
37	0.4106	3.6154	37	46	21
38	0.4286	3.3333	38	16	101
39	0.1625	2.0442	39	15	10
40	0.8614	8.7959	40	29	7
41	0.4907	4.0918	41	30	81
42	1.1156	9.8223	42	54	2
43	0.2658	2.2219	43	17	102
44	5.0863	12.0930	44	55	0
45	0.1566	2.2546	45	38	2
46	0.3170	2.3486	46	18	1
47	0.1135	1.5163	47	37	81

ontinue?

RECNO	AREA	PERIMETER	COV95C2_	COV95C2_ID	COV
48	0.1450	1.9302	48	47	4
49	0.7311	6.1830	49	36	7
50	0.0719	1.6497	50	31	7
51	0.2017	2.2306	51	32	7
52	2.3378	12.2568	52	33	7
53	1.5812	9.5856	53	56	6
54	0.2628	2.2830	54	34	5
55	0.5479	2.8903	55	35	5

```
[illegible]
nter command:
```