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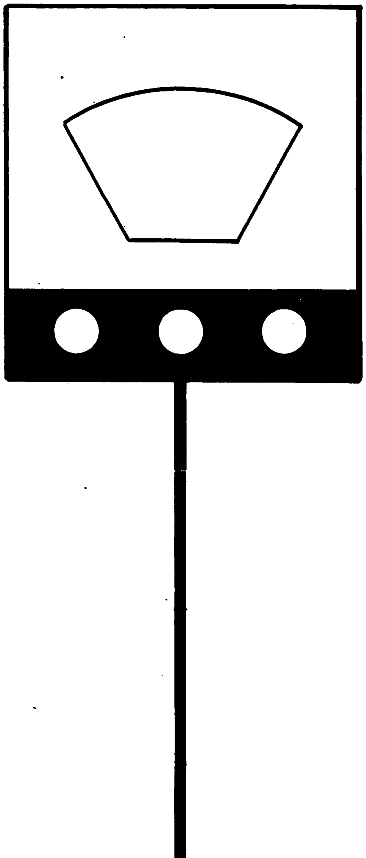

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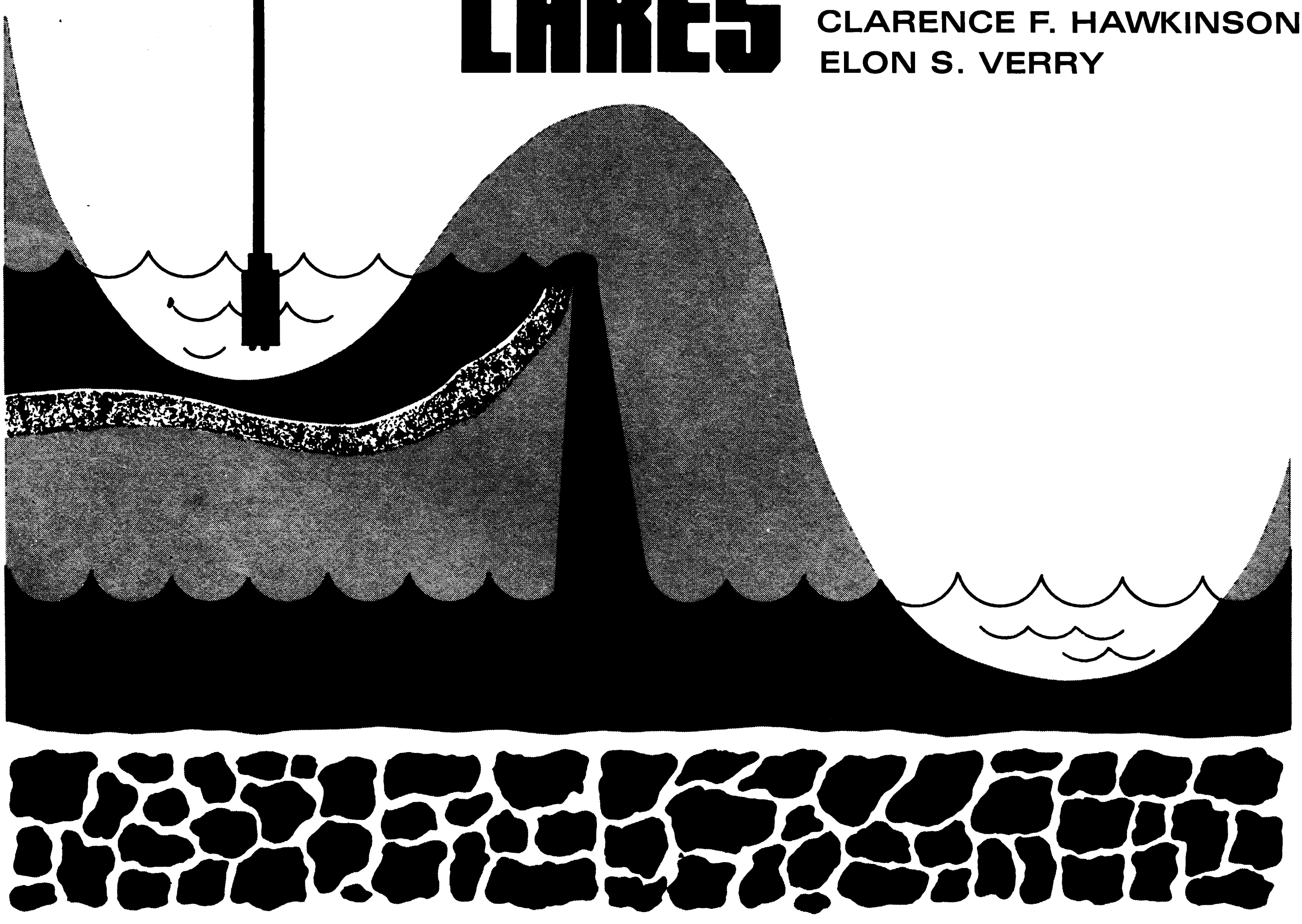

NORTH CENTRAL FOREST EXPERIMENT STATION FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

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SPECIFIC CONDUCTANCE IDENTIFIES PERCHED AND GROUND WATER LAKES

Clarence F. Hawkinson and Elon S. Verry

In north-central Minnesota the water level in lakes may or may not be contiguous with the regional water table. Some lakes are perched above the regional water table and receive water primarily from precipitation and local runoff. Other lakes are simply an exposure of the regional water table and receive large amounts of ground water. In areas with many lakes, the knowledge of which lakes are ground water fed can be used to draw general maps of the regional water table by taking the elevation of ground water lakes as control points to construct contours.

A study to evaluate the usefulness of specific conductance (the ability of water to pass a standard electrical current) as an index of water type in lakes was conducted on a 30-square-mile area near the Marcell Experimental Forest in north-central Minnesota (ca. N 47° 32' Lat., 93° 28'W Long.) (fig. 1).

METHODS OF STUDY

The regional water table was measured by means of 29 wells ranging from 11 to 72 feet deep. One well was fitted with a continuous recorder for water table fluctuations. The others were measured each month for 10 years. Portable field meters were used to measure specific conductance and pH for each of 17 area lakes; all values were corrected to 25°C.

The lowest water table elevation in each well during the 10-year period was used to draw a 5-foot contour map of the regional ground water surface (water table) (fig. 2). Elevations of lakes known to reflect the water table were also used in drawing contours. Arrows were drawn at right angles to the ground water contour lines to indicate the general direction of flow.

RESULTS

Specific conductance values fell into three distinct categories which we termed perched, transitional, and ground water lakes. pH values generally followed the same pattern but lacked the sensitivity of specific conductance (table 1).

Table 1.--*Specific conductance and pH of lakes at 25° C*

Lake	Specific conductance	pH units
PERCHED LAKES		
	µmhos	
Blandin	16	6.2
Willeys	16	6.6
White Porky	18	6.6
Moss	19	6.8
Moon	19	6.4
Spring	20	6.4
Lum	21	6.3
Sawyer	22	6.1
Bog	23	6.6
TRANSITIONAL LAKES		
Burrows	31	6.4
Lost Moose	55	7.4
Burnt Shanty	32	6.9
Buchman	95	8.3
GROUND WATER LAKES		
Sand	144	7.5
Hunter	150	7.5
Cutaway	160	7.6
Lake 19	192	7.2

Perched lakes are fed by precipitation and local runoff. Local runoff is principally subsurface flow resulting from water percolating about 6 inches into the soil and flowing laterally down-slope over the top of a buried clay horizon. Because of these sources, perched lakes have a low mineral content and thus low specific conductance (16 to 23 µmhos) and a low pH (near 6.4).

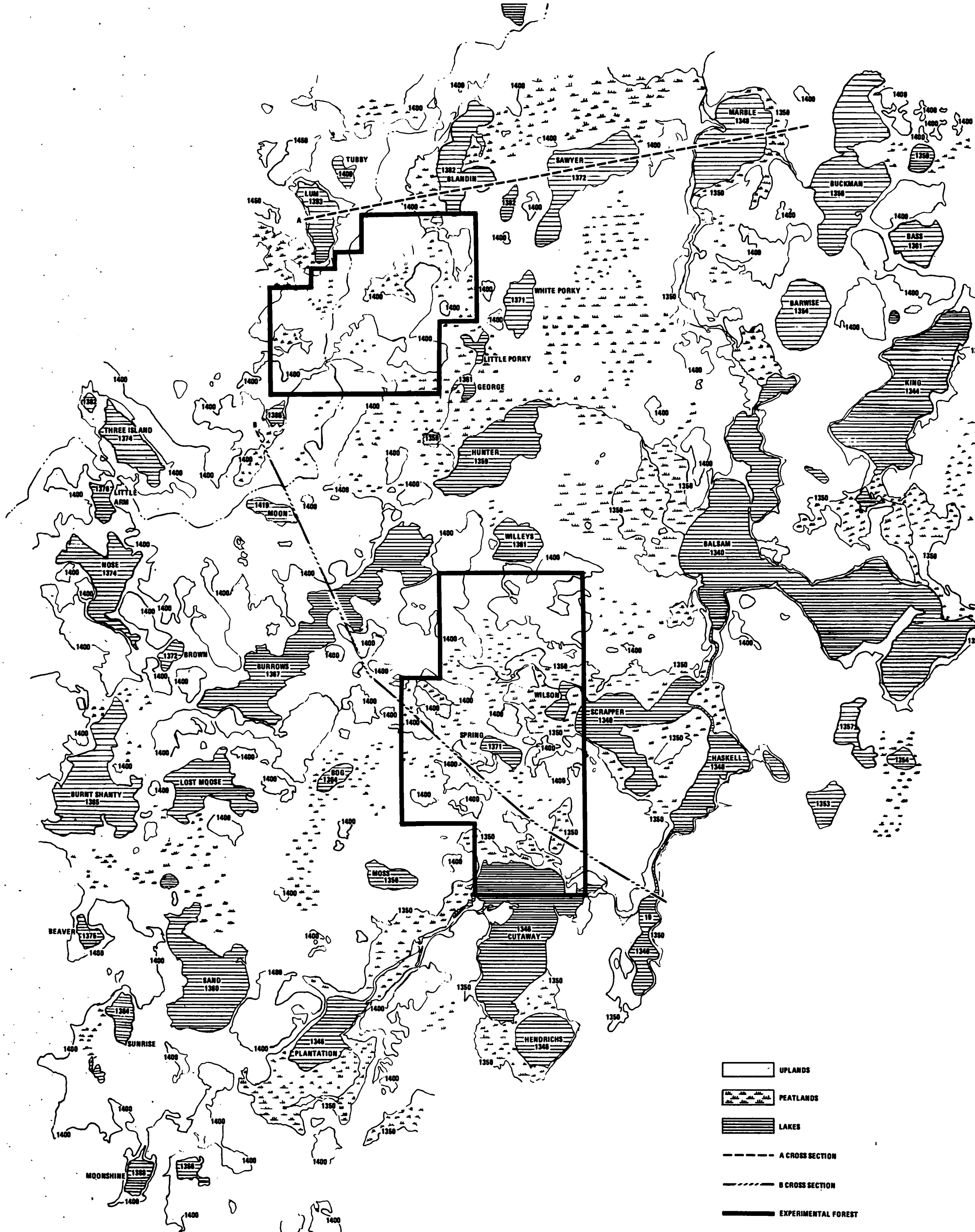

Figure 1.--*Surface contour map (50 foot intervals MSL) of 30 square mile area that encompasses the two units comprising the Marcell Experimental Forest.*

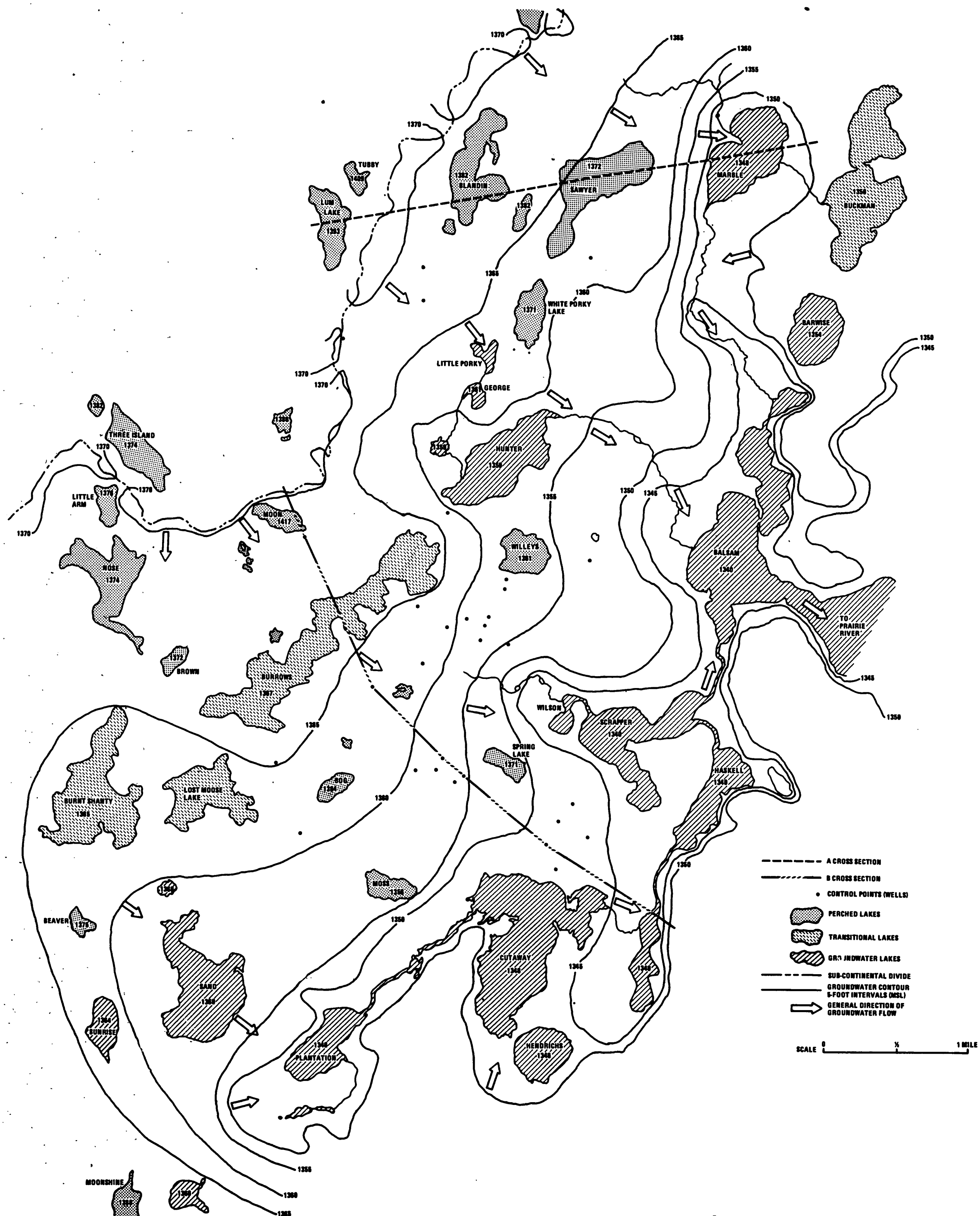

Figure 2.--*Water table map of 30 square mile area that encompasses the two units comprising the Marcell Experimental Forest.*

Ground water lakes receive the same inflow as perched lakes plus a lot of ground water inflow. Ground water entering a lake has traveled some distance through soil parent materials and aquifer sands and contains a high concentration of dissolved minerals, particularly calcium. Correspondingly, specific conductances range higher (144 to 192 μmhos) with a pH of about 7.5.

Transitional lakes in this study have specific conductances ranging from 31 to 95 with a pH of about 7.2. Their water may vary considerably, tending toward perched lakes following snowmelt, and ground water lakes during dry periods.

These classifications were confirmed by a ground water contour map showing water table elevation and direction of flow (fig. 2). Two cross sections were drawn to illustrate relative positions of the ground surface, the lakes, the top of the sand aquifer, and the water table (cross sections A and B, fig. 3).

The water table ranged from 5 to 65 feet below the ground surface at its lowest fluctuation. Annually it fluctuates slightly less than a foot, but over the 10-year period it fluctuated 2-1/2 feet. The aquifer is mostly below a thin layer of glacial till. This till layer separates some lakes and bogs from the ground water system and prevents their water from seeping into the regional ground water system.

Some lakes are perched high above the regional water table; for example, Moon Lake in the west-central part of the study area (cross section B, fig. 3) is more than 40 feet above the regional water table. Many bogs in the area are also perched above the regional water table.[1]

Other "perched" lakes may sit in the ground water system but still be separated from the ground water by lake bottom muds of an organic nature, by till, or by other impervious material. Sawyer Lake in the northeast corner of the study area is an example (cross section A, fig. 3).

Lakes such as Burrows and the unnamed lake east of Cutaway lake (Lake 19) are exposures of the water table (cross section B, fig. 3). No stream flows into or out of Burrows Lake; it probably feeds the ground water system during periods of high precipitation and runoff, and depletes ground water during periods of high evaporation. On the other hand, the unnamed lake and the stream leading from it discharge ground water.

[1] *R. R. Bay. Factors influencing soil moisture relationships in undrained forested bogs. In Int. For. Hydrol. Symp. Proc., Penn. State Univ. p. 335-343. 1967.*

APPLICATION

The correlation between specific conductance and source of water in a lake can be useful in drawing water table maps in areas with many lakes. Needed are only specific conductance values for the lakes (measured during a relatively short period to avoid biasing by large storms) and a surface topographic map (usually available from the U.S. Geological Survey). Specific conductance should not be measured during or within 2 weeks following snowmelt as all values will be low due to dilution. When ground water lakes are identified, crude water table contours can be drawn by using the ground water lake elevations as a control.

Water table maps are useful for planning wells by substracting water table elevations from surface elevations to obtain depth to water. In our study area we found that the highest level of the water table occurred in early July as a delayed result of spring snowmelt; the lowest are usually in March. Water table maps are also useful for locating land fills and sewage renovation areas by knowing the direction of ground water flow and the depth of soil and parent materials above the saturated zone.

The ranges of specific conductance for perched, transitional, and ground water lakes in this study are only relative. Sampling at different times of the year would show different ranges, as would sampling in different areas. Still, specific conductance sampling--if done over a short period (2 weeks or so)--will indicate the existence of perched, transitional, or ground water lakes. Although the extent of perched lakes State-wide is not known, they have been identified in the Suomi Hills area 15 miles west of the Marcell study,[2] and in the pothole region of west-central Minnesota.[3]

[2] *J. Roles, M. B. Hathaway, W. Allen, G. Goltz, J. Mathisen, J. Osborne. Proposed Suomi Hills area management plan. USDA For. Serv. Chippewa Natl. For., Cass Lake, Minn. 60 p. 1974.*

[3] *G. M. Schwartz and P. W. Manson. Pothole drainage and deep ground water supplies. Minn. Farm & Home Sci. 21(3):13-15. 1964.*

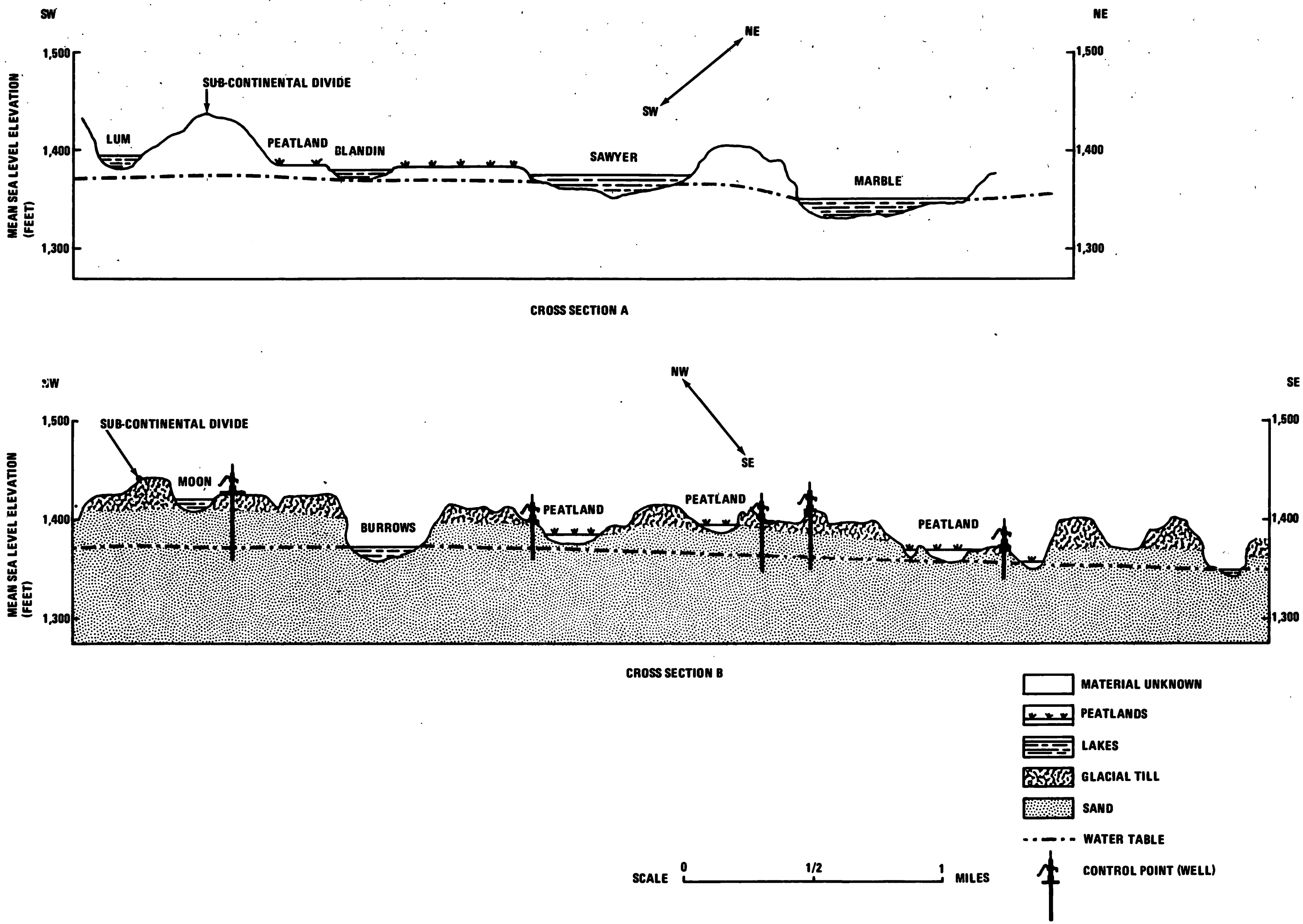

Figure 3.--*Two cross sections of ground water and lakes in 30 square mile area that encompasses the two units comprising the Marcell Experimental Forest.*

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Shows that lakes can be classified into perched, ground water, and transitional categories according to specific conductance values. Confirms the classification with 10 years of water table measurements in 29 wells and discusses several applications of lake specific conductance values.

OXFORD: 116.9--014(047.3)(776). KEY WORDS: water table, limnology, land management, water quality, maps.

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