Frost Table Pattern And Development In Patchy High Arctic Wetlands

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In this talk I will discuss some recent hydrology projects that I have been working on with Hok Woo.

As hydrologists, why do we need to monitor ground thaw?

- Firstly, the position of the frost table tells us a lot about surface water flow: if it's near the surface after the snowmelt then we will have rapid runoff, but if it descends rapidly then much of the snowmelt will move into the ground and we will have higher subsurface flow.
- Evaporation will be affected in a similar way: if the water table is high, then the evaporation rate will be high, whereas if the watertable falls far below the ground then evapotransiration will be reduced.
- Depth of thaw is needed to calculate the contribution of ground ice to subsurface flow.
- It also controls the storage capacity of the ground.
- Nutrient availability

This work has been carried out on Cornwallis Island; near Resolute NWT since 1996, where we have been looking at patchy wetland areas not far from the PCSP; in the McMaster Basin. Hok Woo carried out a great deal of work in the 1970's and '80s in this area.

One site is a patchy wetland area fed by water from various sources such as late-lying snowbeds and thawing ground ice, sometimes producing thermokarst induced wetlands. The water table is measured in wells that extend over and beyond the wetland area. Following snowmelt the frost table is monitored twice weekly by probing next to the water wells. Measurements are reduced to once per week when thaw penetration slows down (after about two weeks). Another site is a riparian wetland associated with a stream; it demonstrates that there is vegetation in the Resolute region, as many of you don't know. This wetland contrasts sharply with the low, desolate terrain that is more common around Resolute.

As table 1 shows, 1997 was a relatively cold and rainy summer with significant snow storage on the wetland. The snow was not completely gone until early July. In 1998 we arrived the first week of June and the snow had already disappeared.

Table 1

General Summer Conditions

Year	Wetland Snow Storage (mm)	Average Air Temperature	Total Summer Precipitation (mm)
1996	126	2.54	32
1997	161	1.95	100
1998	Not available	5.5	22

We have been looking at the frost table patterns that have emerged in these wetlands. Today I will just present the results for one wetland for the 1997 and 1998 seasons (Figure 1). In the cool and wet conditions of 1997, the frost table development within the wetland varies from about 0.3 to 0.5 m. In the gravelly non-wetland area the frost table is slightly deeper, to about 0.6 m. In 1998 a similar pattern developed, but with a slightly deeper frost table. More probing was done in 1998, revealing the maximum depth in a peat mound (0.2 m) that was not found the year before. The frost table extended to 0.6 m in the wetland area and to 0.7 m in the gravelly area.

Development of the frost table over time is shown in the graphs of Figure 2. Concentrating on the data for 1997 and 1998, we can see that thaw starts earlier and descends further in 1998. The water table was higher in 1998 than in 1997, which on first consideration is the opposite of what is expected: In a warmer, drier year the water should have evaporated. During the summer of 1998, the water table was maintained by water melting from an adjacent late-lying snow bank. Without the multi-year monitoring at this site, this effect would not have been picked up. The interaction between different landscape units is clearly important.

Table 2 illustrates the differences in soil water chemistry between 1997 and 1998.

Table 2

GROUNDWATER CONDUCTIVITIES

	1997 µs/cm	1998 µs/cm
Snowbank		
-wetland	44	83
-gravel	54	157
Multi-source		
-wetland	80	189
-gravel	99	284
Ground-ice		
-wetland	127	255
-gravel	93	194
Rejuvenated		
-wetland	110	454
-gravel	125	351

Data for the wetland discussed here is highlighted in table 2. In the cold wet year (1997) the conductivities were lower, and were more than twice the value in 1998. This pattern is consistent for the other wetlands that we monitor. The results suggest that the frost table may have descended into the upper permafrost in 1998.

Table 3 is a summary of the information that has been collected in the execution of this work.

Table 3

Data Availability

- ***Meteorological Information***
  (1996-1999)
- ***Hydrology information***
  (Snow, soil moisture, water table, frost table, surface flow etc) (1996-1999)
- ***Water chemistry***
  (pH, conductivity, plant nutrients) (1996-1999)
- ***Topography, Soils, Vegetation, Ground Ice Content***

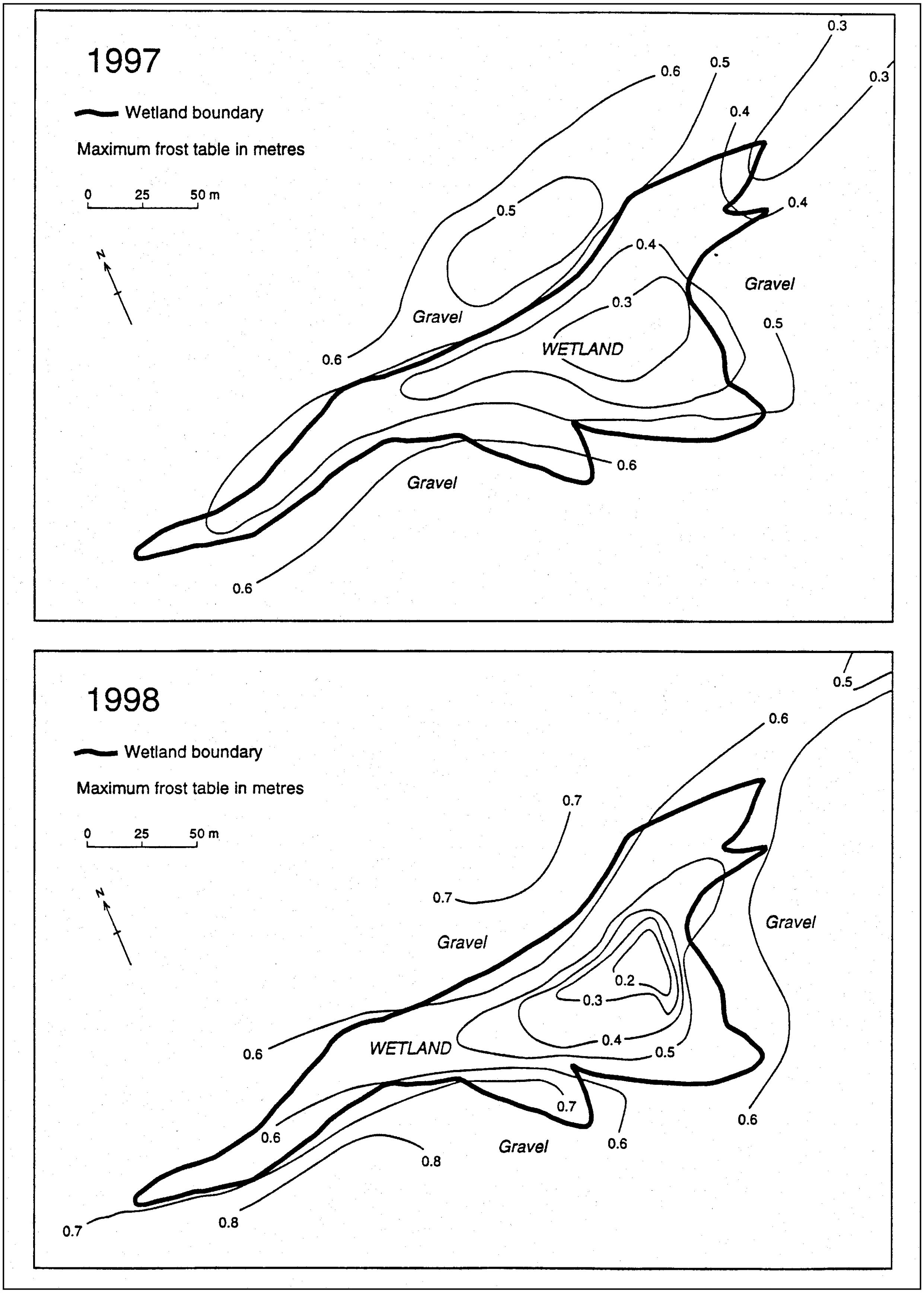

Figure 1

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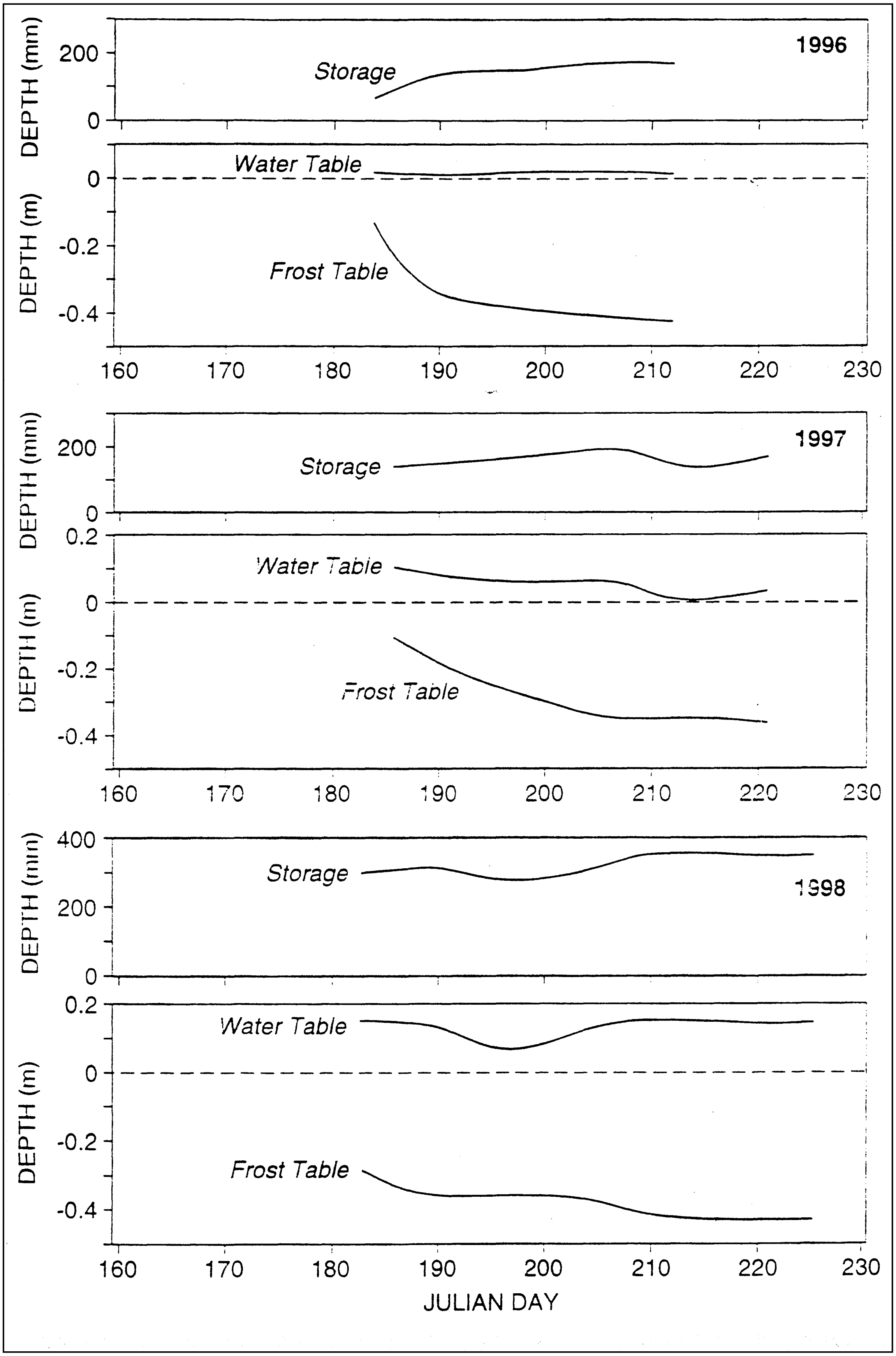

Figure 2

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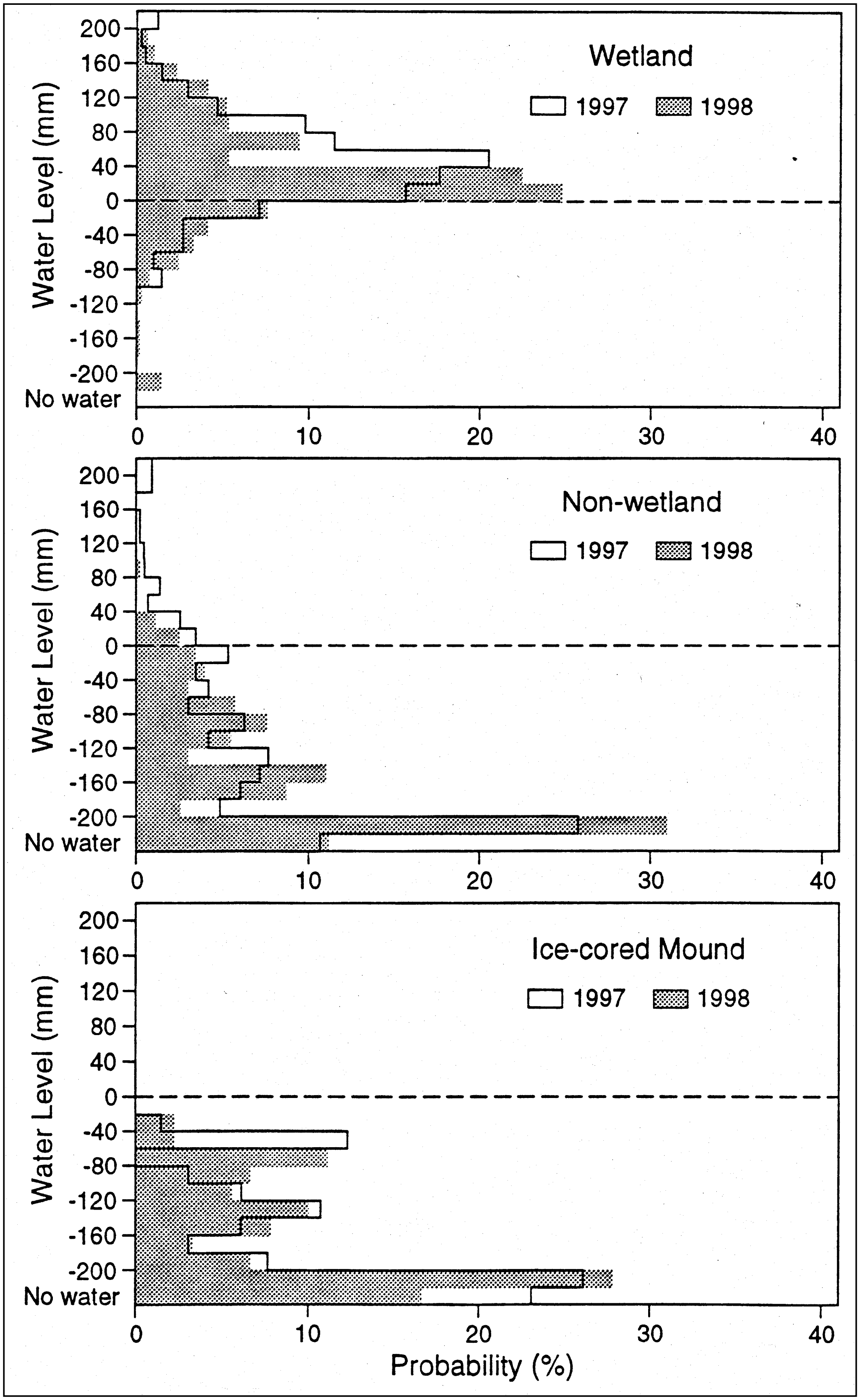

Figure 3

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