

# Evaluating the drying index for the Southern Interior Ecoprovince<sup>1</sup>

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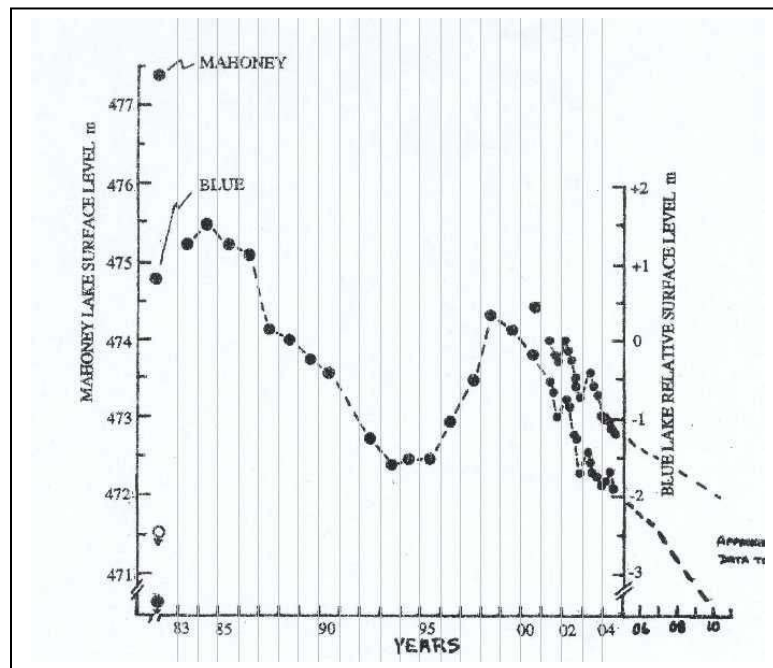
## Introduction

The models of Bunnell et al. (2010a and 2010b) project consequences of drying indices for small lakes and wetlands of the Southern Interior and Central Interior Ecoprovinces. Unpublished data from Riske Creek permitted evaluation of the form of the drying index for the Central Interior Ecoprovince (Bunnell et al. 2010c). Here we report efforts to evaluate the index for the Southern Interior Ecoprovince.

## Data and methods

Finding small lakes or wetlands in the Southern Interior for which ingress or egress of water was not controlled and for which a series of depth measures were available proved challenging. It appears that the relative supply and demand for water has ensured that most streams or lakes capable of storing water have been dammed curtailing unrestricted flow into smaller lakes and wetlands at lower elevations. Tom Northcote provided a series of unpublished depth measurements for two lakes that met the criteria: Mahoney Lake and Blue Lake.

Mahoney Lake is 18 ha in size at an elevation of 474 m above sea level. Blue Lake is 18.9 ha in size at 835 m above sea level. Depth measures in the form received are illustrated in Figure 1 (horizontal lines were inserted after receipt).



**Figure 1.** Raw depth measurements of Mahoney and Blue Lakes as received from Tom Northcote.

Dashed lines of Figure 1 are approximate and not included in the analyses. The data analyzed span 21 years for Mahoney Lake and 5 years for Blue Lake. The exact elevation was surveyed only for Mahoney Lake, so data are scaled in terms of relative decline with 10 m being assigned the maximum depth recorded and 0 assigned the minimum depth for each series. Because the downscaled climate data are relatively coarse, where several measurements were acquired in a single year the minimum for that year was used.

The drying index initially proposed by Bunnell and coworkers, and subsequently evaluated by Bunnell et al. (2010c) for the Central Interior, is the product of two climate variables: annual precipitation as snow

(PAS) and summer heat-moisture index (SHM index). PAS is expected to provide a primary water source (input) for wetlands, while SHM is expected to provide an indication of drying trends (output) for wetlands.

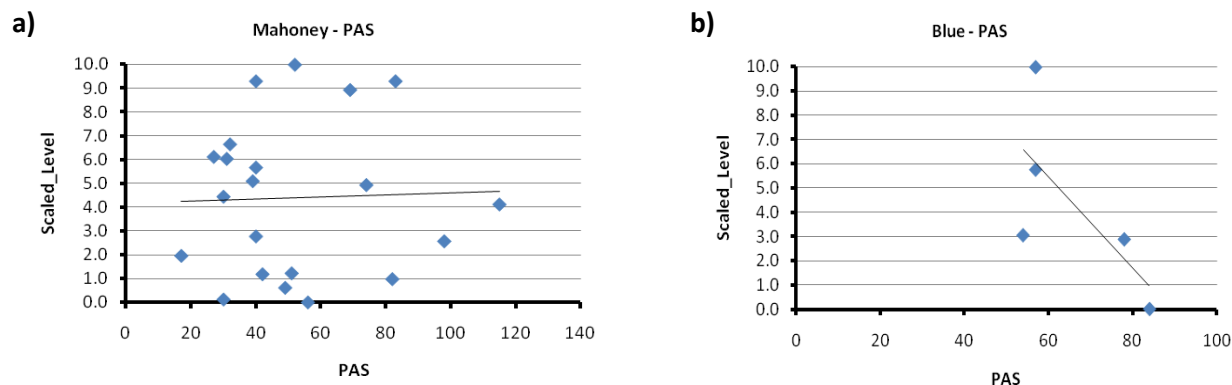
- PAS is a direct measure of snow precipitation (mm). It is provided on a calendar year (as opposed to preceding fall and current winter). That hinders evaluating individual year responses, but has little effect when merged over longer periods. Higher values represent greater water input.
- SHM is generated by ClimateBC<sup>2</sup> using the equation:  $(MWMT * 1000)/MSP$ , where MWMT is the Mean Warmest Month Temperature (°C) and MSP is Mean Summer (May – Sept) Precipitation (mm). SHM index is a derived variable, used as a limited proxy for direct measures of humidity or evaporation and transpiration, which are often unavailable (Tuhkanen 1980). Higher values of the SHM index represent a stronger drying tendency relative to lower values (due to less precipitation and/or higher temperature).

Climate data for each individual Lake were downscaled from ClimateWNA. Measured water depths were regressed against these two variables plus the component variables of SHM: mean warmest month temperature and mean summer precipitation. Regression analyses also included the multiplicative formulation of the drying index suggested by Bunnell et al. (2010c) based on their evaluation for the Central Interior Ecoprovince. Simple linear regression was employed.

## Results

### Annual snowfall

There was no relationship between measured water depth and annual snowfall (PAS) for Mahoney Lake, but an apparent downward trend for Blue Lake; neither trend is significant (Figure 2).



**Figure 2.** Scaled water level (m) versus annual precipitation as snow (mm) for **a)** Mahoney Lake and **b)** Blue Lake in the Southern Interior Ecoprovince.

The common period of measurement for Mahoney and Blue lakes is the 5-year period 2000 to 2004. During that period, Mahoney Lake (elevation 474 m) received a mean annual snowfall of 42.8 mm (range: 30 to 56 mm). Snowfall during the 1990s averaged 55.3 mm. During the same common period of measured water depths, Blue Lake (835 m) received a mean annual snowfall of 66 mm (range 54 to 84 mm). Note that the current temporal trend for both lakes is strongly downward (Figure 1), but Mahoney Lake has declined before only to partially recover. The current depth of Mahoney Lake is the lowest it has been over the 21-year measurement period; the same is true for Blue Lake over a 5-year period. Over the 21-year period for which data were analyzed, Mahoney Lake depth has declined about 3.5 m. During a shorter and more recent period water, depth of Blue Lake has declined about 2.5 m.

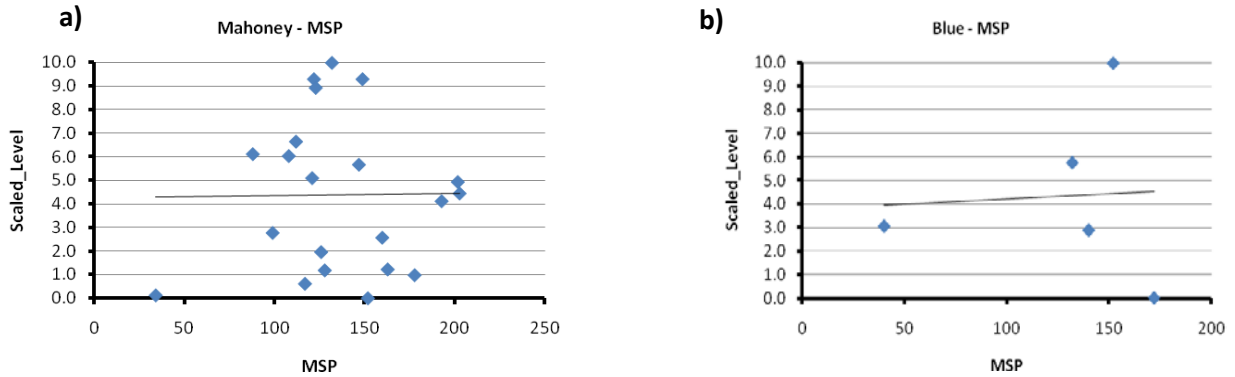
<sup>2</sup> <http://www.genetics.forestry.ubc.ca/cfcg/ClimateWNA/ClimateWNA.html>



°C for Mahoney and 19.4 °C for Blue Lake. Temperature is projected to increase slightly to 22.1 °C by the 2050s for Mahoney Lake.

**Mean summer precipitation**

Mean summer precipitation is the second component of the summer heat-moisture index. Greater precipitation yields a lesser value for the index. There was no relationship between mean summer precipitation and measured water depths in either lake.



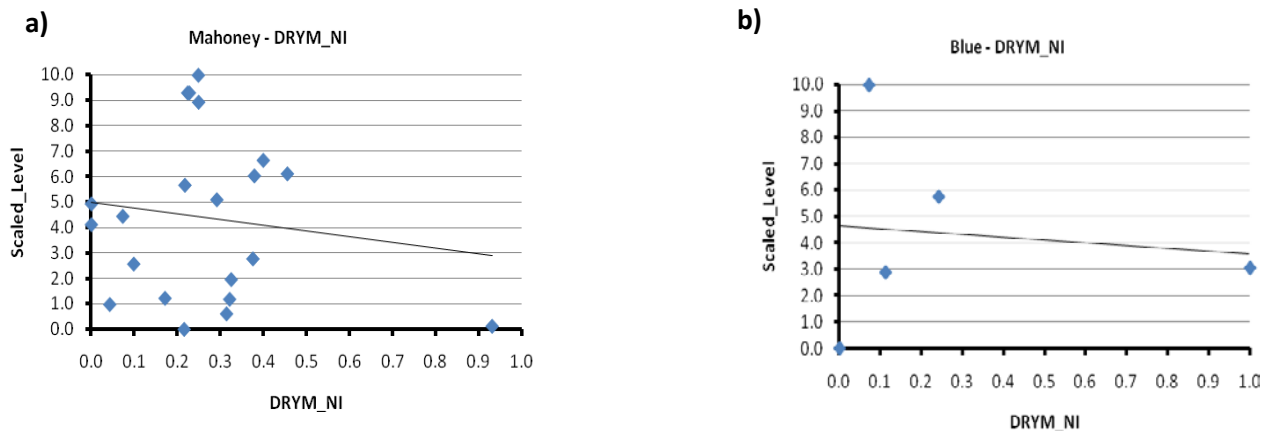
**Figure 5.** Scaled water level (m) versus mean summer precipitation for **a)** Mahoney Lake and **b)** Blue Lake in the Southern Interior Ecoprovince.

Downscaled precipitation for the two lakes during the comparable period of 2000 to 2004 were 104.6 mm (range 34 to 152 mm) for Mahoney and 127.2 mm (range 40 to 172 mm) for Blue Lake. The minimum values occurred in 2003 yielding the high SHM value for that year. Summer precipitation for Mahoney Lake is projected to increase to 137 mm by the 2050s, which could slow the rate of drying.

**Drying index**

The drying index recommended by Bunnell et al. 2010c) relies on normalized values to encompass the regional range in variation experienced:

$$\text{Drying index} = (\text{normalized SHM} \times \text{inverted normalized PAS})$$



**Figure 5.** Scaled water level (m) versus the normalized drying index for **a)** Mahoney Lake and **b)** Blue Lake in the Southern Interior Ecoprovince.

The drying index is itself normalized, so ranges for 0 to 1 over the range of climate variables assessed. The water levels respond in the direction anticipated, but with this small sample size the relations are not significant for either lake.

## Discussion

Bunnell et al. (2010c) were unable to evaluate effects of snowpack on drying because elevation among measured wetlands varied by only 50 m and there was insufficient range in snowpack. Mahoney and Blue lakes differ by 361 m in elevation. However, snowfall during the most recent common five years of measurement differed relatively little – 42.8 and 66 mm for Mahoney and Blue lakes, respectively. Nor is snowfall substantial. We found no significant relation between measured water depth and regional snowpack for individual lakes in the Southern Interior Ecoprovince. That finding does not imply there is not an effect across lakes, particularly under a wider range of snow fall.

The inability of analyses to date (here and in Bunnell et al. 2010c) to find a significant relation between annual snowfall and water depth could have two causes. The first is the relatively small range in snowfall addressed. The second is that all analyses to date have been on the basis of individual lakes and wetlands and snowfall has been derived for the immediate vicinity. The wetland or lake is likely to be drawing water from a much larger area. Although depth measurements have been acquired differently across the wider range of samples, provided measured depths could be found from a larger range of snow fall, it may be possible and informative to: 1) combine a wetlands from a wider range of snowfall into a single analysis, and 2) incorporate some form of watershed and neighbourhood modeling to assess snowpack over a larger area.

The trend for both lakes with SHM was as expected – a decrease in water depth with increasing evapotranspiration. Neither trend was significant but are very likely to become so under current climate projections. Temperature of the warmest month and mean summer precipitation determine the SHM. The two lakes responded somewhat different to temperature of the warmest month. Blue Lake showed the expected decrease with increasing temperature ( $p < 0.05$ ); Mahoney Lake showed no significant relationship. Neither lake showed a significant relationship with mean summer precipitation. In short, while the combined effect of evapotranspiration on water depth was as expected for both lakes, it is equivocal whether temperature or precipitation are having the major effect. In the Central Interior Ecoprovince, it was summer drought (Bunnell et al. 2010c). In the southern Okanagan, the sparse evidence suggests temperature (e.g., Figure 4). The southern Okanagan is markedly warmer than Riske Creek area where the drying index was first evaluated. The projected climate indicates that summer temperature will be increasingly influential.

Water levels of the two lakes evaluated respond to the drying index in the fashion anticipated, but the accuracy is low. There likely are two reasons. The first is the small sample size. The second is that using localized PAS is an inadequate index of water input; ground water likely is drawn from a much larger area. The latter reason presents a challenge. Over large areas, like an Ecoprovince, the current simple version of the drying index will predict the direction of drying accurately, but the extent of drying or the rate of drying will have high variability for any individual wetland or pond. Accuracy for any specific wetland likely could be improved by drawing from complete or partial watersheds. That would be onerous for large areas and has not yet been tested.

## Literature cited

- Bunnell, F.L., Wells, R., and Moy, A. 2010a. Vulnerability of wetlands to climate change in the Southern Interior Ecoprovince: a preliminary assessment. Final Report to Canadian Wildlife Service and DUC. 14 pp.
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