# Estimation of Leaf Wetness Duration Using An Empirical Model


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## 1. INTRODUCTION

Estimation of leaf wetness duration (LWD) facilitates assessment of the likelihood of outbreaks of many crop diseases. Models that estimate LWD may be more convenient and grower-friendly than measuring it with wetness sensors. Empirical models utilizing statistical procedures such as CART (Classification and Regression Tree; Gleason et al., 1994) have estimated LWD with accuracy comparable to that of electronic sensors. When an empirical approach is used to build a LWD model, a key step is to determine which variables to utilize for the estimation. In this study, possible combinations of input variables, including cloud cover and air temperature near the surface (0.3-m height), were used to build an accurate LWD estimation model whose input variables can be acquired at minimum cost.

## 2. MATERIALS AND METHODS

### 2.1 Acquisition of input data

Hourly measurements of air temperature, RH, wind speed were collected from May to September in 1997, 1998, and 1999 at 15 sites in Iowa (IA), Illinois (IL), and Nebraska (NE), USA. Flat, printed-circuit wetness sensors (Model 237, Campbell Scientific, Logan, UT) and thermocouples (Model 107, Campbell Scientific) were installed at 0.3-m height to acquire wetness measurement and air temperature near the surface. In 1999, cloud cover data were obtained from SkyBit, Inc. (Boalsburg, PA) for each site.

### 2. 2 Classification and Regression Tree procedure

A classification and regression tree (CART) technique was used to build LWD estimation models with S-plus (Math Soft Inc., Cambridge, MA; Venables and Ripley, 1999). Combinations of air temperature at 0.3-m height, cloud cover, air temperature at 1.5-m height, RH, wind speed, and dew point depression were used as input variables. Only night hours (from 20:00 until 7:00) were included in the data set. A model that had the lowest misclassification rate in the prediction step was compared with the CART/SLD model (Gleason et al. 1994).

### 2.3 Analysis of wetness estimation

For analysis of model performance, measurements from wetness sensors were assumed to be true and deviations of model estimates from measurements were considered to be errors. Mean daily difference between measured and model-estimated LWD, and the percentage of hours in which each model identified wetness or dryness correctly, were calculated as mean error and accuracy. The CSI (Critical Success Index) was also used to evaluate accuracy in predicting occurrence of wetness (Schaefer, 1990).

## 3. RESULTS AND DISCUSSION

### 3.1 Model selection

Most models that used air temperature at 0.3-m height as an input variable showed lower hourly misclassification rates (i.e., wet hours misclassified as dry or vice versa) for LWD estimation than for models using other input variables (data not shown). Model B22, which used RH, air temperature at 0.3-m height, and wind speed as input variables, had a relatively low misclassification rate in wetness or dryness estimation as well as in wet event identification.

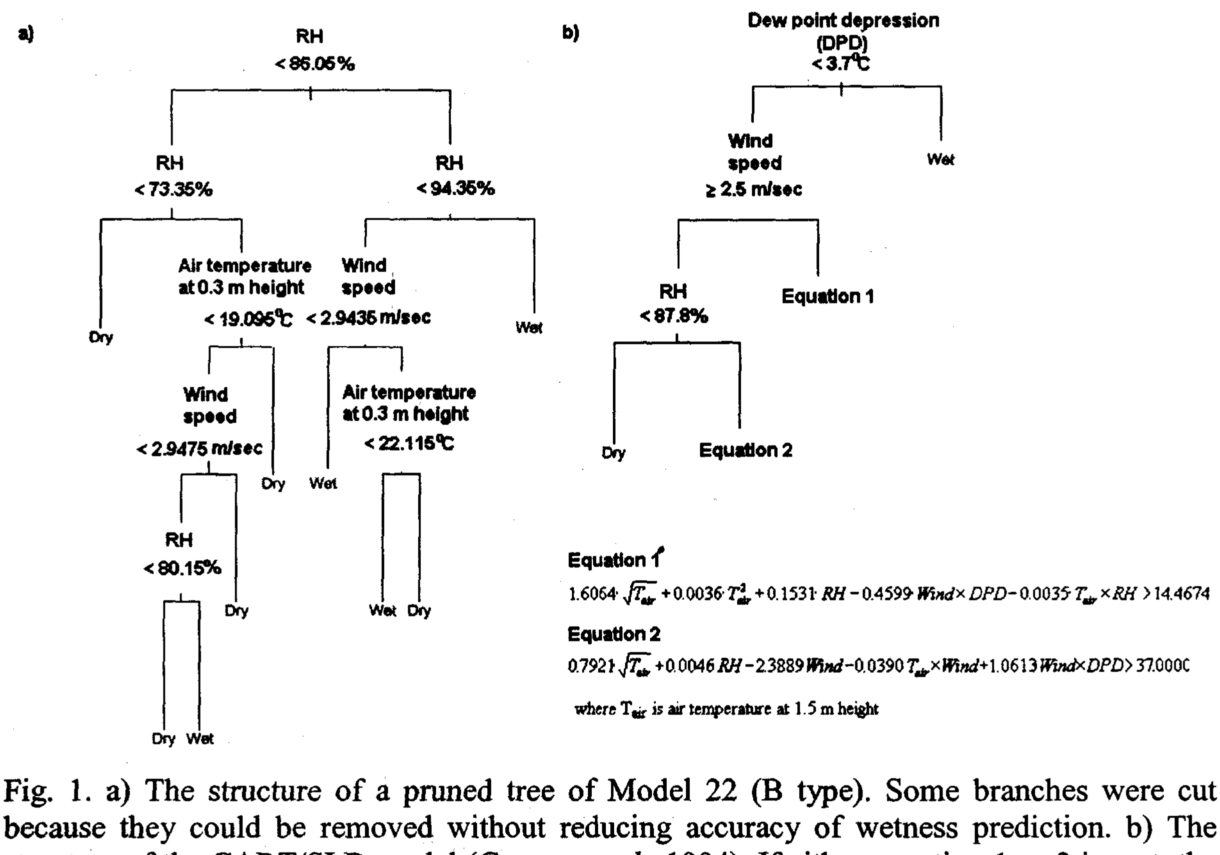


Fig. 1. a) The structure of a pruned tree of Model 22 (B type). Some branches were cut because they could be removed without reducing accuracy of wetness prediction. b) The structure of the CART/SLD model (Geason *et al.*, 1994). If either equation 1 or 2 is met, the hour was classified as wet hour.

### 3. 2 Comparison of Model B22 with the CART/SLD Model

Overall, Model B22 and the CART/SLD model estimated LWD within 1 h per night. Model B22 overestimated wetness duration by an average of 0.9 hr/day, whereas the CART/SLD model underestimated wetness duration by 0.2 hr/day (Table 1).

When the difference between the temperatures near the ground (0.3 m) and at the standard height for measurement (1.5 m) was large, wetness was measured at much lower values of the 1.5-m-level RH than otherwise (Fig 1). During calm nights, the net radiation is negative and the temperature of surfaces, e.g. leaves or wetness sensors, is lower than that of air, which favors dew formation. Model B22 may, thus, be able to identify dew events near the ground surface more accurately than the CART/SLD model since it used near-surface temperature observation. Using temperature measured at the height of 0.3 m, however, seemed to make Model B22 overestimate wetness events, resulting in mean accuracy similar to that of the CART/SLD model.

The relatively minor improvement of B22 in accuracy of LWD estimation compared to the CART/SLD model suggests that the CART/SLD model is preferable operationally, since no additional installation of sensors is necessary where a standard weather station is operational. Site-specific data for the variables required in the CART/SLD model, furthermore, are available as a commercial service. On farms where no standard weather station is present, therefore, it would be beneficial to use the CART/SLD model to predict wetness duration, using input data either from nearby weather stations or site-specific data.

Table 1. Mean Error and Accuracy of wetness estimation.

| Locations | Nights | Mean Error (h/night) (SEM) | | Accuracy (%) | |
|---|---|---|---|---|---|
| | | CART/SLD | Model B22 | CART/SLD | Model B22 |
| Lewis, IA | 215 | 0.6 (0.23) | 1.2 (0.24) | 85.3 | 84.0 |
| Crawfordsville, IA | 308 | 0.5 (0.17) | 0.8 (0.16) | 87.4 | 87.7 |
| Belleville, IL | 275 | 2.0 (0.18) | 2.4 (0.17) | 83.4 | 84.2 |
| Monmouth, IL | 336 | -1.3 (0.21) | 1.0 (0.21) | 82.5 | 82.3 |
| Red Cloud, NE | 202 | -1.5 (0.27) | -0.3 (0.24) | 84.0 | 86.7 |
| West Point, NE | 199 | -1.7 (0.17) | -0.5 (0.15) | 86.6 | 89.6 |
| All sites | 1535 | -0.2 (0.11) | 0.9 (0.10) | 84.7 | 85.5 |

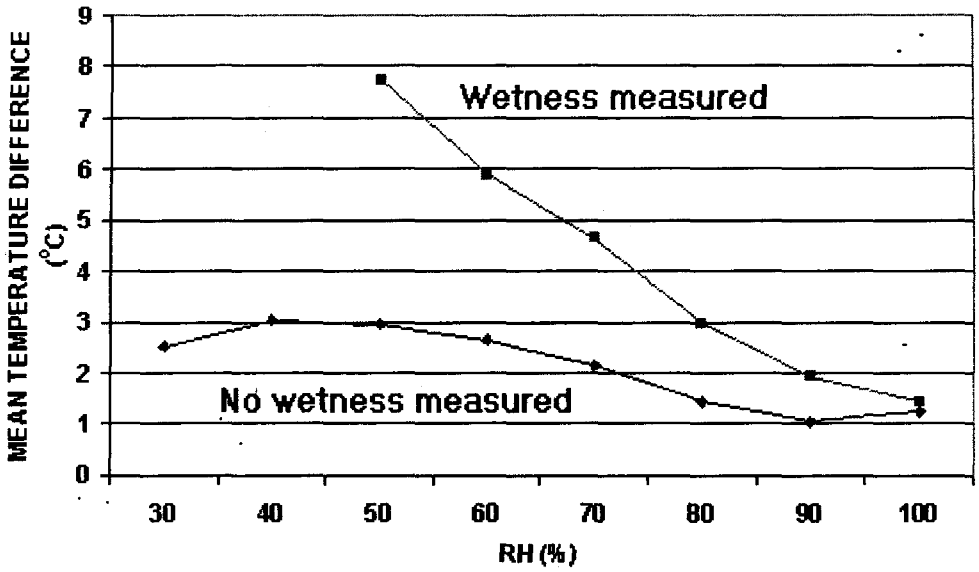


Fig. 2. Mean difference of temperature between 1.5 m and 0.3 m height under calm conditions (wind speed < 3 m/sec) at night (20:00 to 7:00) and measured wetness. When the temperature difference between 1.5 m and 0.3 m was less then 2 °C, wetness was observed only at high humidity. Wetness was usually observed when the temperature difference was larger (upper curve).

## REFERENCES


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