**Some Sensitivity Analyses of an Hourly
Soil-Plant Water Relations Model**

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MASTER

Environmental Sciences Division Publication No. 847

OAK RIDGE NATIONAL LABORATORY

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SOME SENSITIVITY ANALYSES OF AN HOURLY SOIL-PLANT
WATER RELATIONS MODEL

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ABSTRACT

LUXMOORE, R. J., Janice L. STOLZY, and J. T. HOLDEMAN. 1976. Some sensitivity analyses of an hourly soil-plant water relations model. ORNL/TM-5343. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 59 pp.

Nineteen parameters representing landscape, plant, and soil characteristics were examined for their influence on midday plant water relations, daily fluxes and monthly water balance components predicted by a soil-plant-water relations model having hourly resolution. A standard set of parameters was chosen to represent a hardwood forest on ridge top soil in the Oak Ridge, Tennessee area during a representative July (summer) month. Each parameter was varied through a range with all other parameters held at the standard value. The results of the study showed that the model was sensitive to nine plant parameters in noon, daily and monthly results. The ten other parameters had partial or no influence on the simulations. Two leaf characteristics and two landscape properties cause the model to be sensitive in midday values but less sensitive in monthly results due to the negative feedback aspects of the model. Five parameters had almost no influence on the model results in the case examined. The canopy interception parameter had almost no influence on the model results on sunny days, but was a significant component of the monthly water balance. The study highlighted the importance of the root and stem resistances to water flow in influencing plant water status and the monthly water balance.

This study has provided an assessment of the model stability to wide ranges of parameter values and suggests the model's utility in a

range of applications. These would include forest and agricultural crops on most soils and in diverse landscape situations. Further, the consequences of using parameters with high uncertainty in an application may be partially evaluated from these sensitivity tests.

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INTRODUCTION

Sensitivity analyses of parameters in models provide information about the relative importance of parameters in determining the simulation results. On one hand, model output may not be affected by large changes in an input value. These insensitive parameters need not be determined with accuracy in the field for application with the given model. . Alternatively other parameters may have large effects on model performance and should be accurately determined for the model application. Sensitivity analyses may also be helpful in gaining insights into the behavior of real world phenomena which have not been well characterized.

There are several aspects of soil-plant-water flow that have a limited quantitative understanding although the basic physics and physiology of the system is qualitatively well known (Slatyer 1967, Kozlowski 1968). The Prosper model of atmosphere-soil-plant water flow (Goldstein and Mankin 1972) describes the basic flows and water status of vegetated land on a daily basis. This model has been made into an hourly version as part of the development of the Terrestrial Ecosystem Hydrology Model (Huff et al. 1976).

The structural equations in Prosper represent a set of hypotheses and theories coupled in series and parallel and the results from any one simulation are determined by these hypotheses and theories. The formulation of the model is based on rather tenuous data in some of its aspects. For example, the resistance to water flow in the stem has a value of 5000 days in the daily Prosper model (Goldstein, Mankin and Luxmoore 1974). This value was obtained from Cowan's estimate of

internal crop impedance to water flow (Cowan 1965). Prosper also has root conductivity terms that were defined as 10^6 times the soil hydraulic conductivity in the two soil layers with roots. These values change each day with change in soil water content. Again little was known about root conductivity functions and an intuitive guess was used in the original model structure. The main purpose of these sensitivity analyses is to explore a physically and physiologically sensible range of parameter values to determine the effects predicted by the hourly Prosper model on the water budget of a forest. These tests will provide insights for the design of experiments to measure stem resistance, root conductivity or other components of this type of soil-plant water continuum. Further, the study will provide a necessary assessment of the model performance and stability over a wide range of parameter values. The application of the model to a wide range of soil-plant systems may be attempted if the model exhibits reliable performance and stability in sensitivity tests. A standard set of parameters were chosen to represent the conditions of an oak forest on a forest soil during an average July month at Oak Ridge, Tennessee.

METHODS

The standard plant properties used in the model were similar to those reported by Goldstein and Mankin (1972) based on data obtained in eastern Tennessee from the Walker Branch watershed study and the Liriodendron forest study (Ecological Sciences Division Annual Progress Report 1971). The standard soil properties for Fullerton cherty silt-loam were obtained from data reported by Peters et al. (1970). Their

values of saturated hydraulic conductivity were exceedingly high and values about ten times less were chosen. These lower values gave matching factors (ratio between measured and calculated saturated hydraulic conductivity) obtained in the calculation of soil hydraulic properties (Luxmoore 1973) that were of the same order reported in other studies (e.g., Green and Corey 1971). The soil in the model applications was divided into five layers in all cases with the first layer having A horizon properties, the second layer B1 properties and the lower layers had B2 horizons characteristics. A set of July meteorological data with characteristics close to the average were selected from NOAA records (ATDL 1972). July 1953 gave the closest agreement and these daily values were used in all the simulations (listing in appendix). The model was run consecutively for three months with the same monthly meteorological data to eliminate the effects of initial values on the sensitivity tests. Preliminary tests showed that by the third month the major influences of initial conditions were eliminated. The results presented represent unconfounded effect of the parameter on the simulation output without confounding effects of initial conditions.

The nineteen parameters listed in Table 1 were varied in the ranges indicated in the table (all other values held at the standard value). Interaction effects between parameters are not reported here. The following outline indicates the method by which the parameters enter into the model calculations.

Table 1. List of parameters and values used in sensitivity analyses.

VARIABLE	DESCRIPTION	DIMENSIONS	VALUES	RESULTS	
				TABLE	FIGURE
AZIM	Azimuth of slope	degrees	180,360	2a-c	1
INCL	Inclination of slope	degrees	0*, 30, 45, 60, 75		1
ALBS	Summer albedo	-	0, .06, .12*, .24, .48, .75		2
SDRAG	Canopy wind speed coefficient	-	.1, .4, .6*, .9		3
EPXMAX	Interception storage	cm	.0001, .02, .04, .063*, .08, .1	3a-c	4
ALMAX	Maximum leaf area index	cm ² ·cm ⁻²	.01, .5, 1, 2, 4, 6*, 8, 12		5
TMS	Minimum surface resistance	sec·cm ⁻¹	0, 1, 2*, 4, 5, 10, 15		6
RESS	Maximum surface resistance	sec·cm ⁻¹	10, 25, 50, 150, 250*, 500		7
PWPS	Max. surface potential for max. resistance	bars	-5, -10, -20, -30, -34*, -40, -60		8
POWS	Exponential power term	-	-.3, -.4, -.5*, -.6, -.8		9
RSTEM	Stem resistance	days	50, 500, 5000*, 25000, 50000	4a-c	10
RLIT	Litter resistance	days	0, 300, 3000, 30000, 300000*, 900000		11
ARAT	Proportional distribution of roots	-	.001, .1, .4, .6*, .9, 0.999		12
AT(1)	Area density of roots-layer 1	cm ² ·cm ⁻²	.001, .01, .2*, .5, .7, .9		13
AT(2)	Area density of roots-layer 2	cm ² ·cm ⁻²	.001, .01*, .2, .5, .7, .9		14
RTCON1	Root conductivity factor-layer 1	-	.001, .01, .1, 1, 20*, 100, 1000	5a-c	15
RTCON2	Root conductivity factor-layer 2	-	.001, .01, .1, 1, 40, 400*, 1000		16
FACTOR	Saturated hydraulic conductivity factor	-	x.01, x.1, x1*, x10		17
DL(I)	Soil layer thickness (2nd-5th layers)	cm	30, 60*, 120, 240		18

*indicates standard value.

xindicates multiplication.

AZIM, INCL These are both used in subroutine ASPECT to determine an equivalent location on the earth's surface having the same exposure to the sun as the simulated slope. The methods of equivalent slope theory are used to determine the daily radiation and daylength on the slope with the given azimuth and inclination (Huff et al., 1976). Latitude of the slope is also used in these calculations, however this quantity was not varied in these sensitivity tests.

ALBS The albedo of the vegetation is used to determine the daily solar energy available (SOLAR) for evapotranspiration from the total incoming radiation (TOTSOL) $SOLAR = TOTSOL * (1. - ALBS)$

SDRAG The wind drag coefficient determines the effective wind speed (EWIND) in the canopy from the above canopy wind speed (WIND) which is read in as input data. $EWIND = WIND * SDRAG$. EWIND is then used in empirical equations to determine the boundary layer diffusion resistance to heat and vapor flow.

EPXMAX During rainfall (PREC), the summer interception storage by vegetation and litter must be filled from its current value (SCEP) to its maximum storage value (EPXMAX) before water infiltrates (FILT) into soil.

$$FILT = PREC - (EPXMAX - SCEP)$$

ALMAX The leaf area index during the summer (ALMAX) enters into the calculations of the vapor loss from and liquid flow to the evapotranspiration surface. These involved computations are described in the appendix of Swift et al. (1975).

TMS, RESS, PWPS, POWS These four terms determine the characteristics of the following empirical relationship between surface resistance (RX) and surface water potential (PWP), where EXP is the base of the natural logarithm. PWPS and PWP are in absolute values.

$$RX = TMS + (RESS - TMS) * EXP (POWS * (PWPS - PWP))$$

TMS is the minimum surface resistance

RESS is the maximum surface resistance

PWPS is the water potential at which the surface resistance becomes maximum

POWS is the exponential power factor that determines the increase in RX per unit of PWP

RSTEM, RLIT, ARAT, AT(1), AT(2), RTCON1, RTCON2 are all plant terms incorporated into the equations for liquid water flow solved by electrical network methods as outlined by Goldstein, Mankin and Luxmoore (1974).

SCON The standard saturated conductivity values (SCON) for the soil layers are multiplied by the values shown in Table 1 for the sensitivity tests. Each input value of saturated conductivity is used to obtain a matching factor that is applied to the range of calculated unsaturated hydraulic conductivity values to give scaled values appropriate for each application. Hydraulic conductivity determines the water flow rate between soil layers and the water flow rate to roots. These flows are included in the electrical network equations used to solve the liquid water flow to the leaf surface.

DL The soil layer thickness enters into the water potential gradient component of soil water fluxes (FLOW)

$$\text{FLOW} = \text{COND} * \frac{(\text{SPOT}(1) - \text{SPOT}(2))}{(\text{DL}(1) + \text{DL}(2))/2.}$$

where COND is the average soil hydraulic conductivity between the two soil layers and SPOT is the soil water potential.

RESULTS

July Water Balance

The mass balance equation for the month relates the inputs, outputs and changes of storage. In this study the equation is

INPUT	=	ΣOUTPUTS	+	ΣCHANGE IN STORAGE
		interception evaporation		
		transpiration		interception
precipitation	=	soil evaporation +		soil water
		drainage		
		runoff		

Change in interception storage was zero in all cases since initially the value was zero and at the end of the month water in interception storage had completely evaporated. For purposes of comparison the mass balance equation was normalized by dividing each of the components by the monthly precipitation. These normalized values are presented in the figures which follow.

Slope and Canopy Parameters (Fig. 1, 2, 3, 4)

The comparison of north (AZIM = 360) and south (AZIM = 180) facing slopes showed surprisingly little change in the components of the water balance for slope inclinations up to 75° (Fig. 1). However, the differences in solar radiation received on sloping surfaces are at a minimum

ORNL-DWG 75-14012

Fig. 1. Sensitivity of July water balance components to change in azimuth (AZIM) and inclination of land surface (INCL).

ORNL-DWG 75-14013

Fig. 2. Sensitivity of July water balance components to change in summer albedo (ALBS).

ORNL-DWG 75-14014

Fig. 3. Sensitivity of July water balance components to change in summer canopy wind coefficient (SDRAG).

ORNL-DWG 75-14015

x STANDARD VALUE

JULY PRECIPITATION = 10.8 cm

POTENTIAL EVAPORATION = 12.3 cm

Fig. 4. Sensitivity of July water balance components to change in summer canopy interception storage (EPXMAN).

during the summer period in the northern hemisphere. Also the model simulations are adjusted to a horizontal area basis. Thus a 75° slope has a larger actual area with lower irradiance per unit area than a horizontal surface resulting in the total irradiance being similar for both surfaces. Larger differences would be expected during winter months. There was no significant effect of either azimuth or slope on the proportion of water taken up from the first soil layer, which was 82% for slopes less than 45° .

An increase in albedo (ALBS) of the canopy induced reductions in both interception evaporation and transpiration and an increase in drainage (Fig. 2). In the range of vegetation albedos from 0.05 to 0.25, the model has a low sensitivity. Similarly, there were no effects on the distribution of root water uptake.

The wind speed given for a particular day is multiplied by SDRAG in the model to give the estimated wind speed in the canopy. There was a slight increase in interception evaporation and concomitant decrease in transpiration with increase in SDRAG (Fig. 3). Wind speed is used in an empirical equation to calculate boundary layer diffusion resistance. The resistance value in turn is used in the evapotranspiration (ET) equation. The model has a low sensitivity to wind speed.

Interception storage represents the combined thickness of surfaces that can be wetted by rain per unit soil area. It is composed of leaf, stem, twig, bark and litter surfaces. Initial tests showed that a value of 0.0635 cm thickness was needed to give good agreement with the Helvey and Patrick (1965) empirical equations. Interception increased

with increase in EPXMAX and transpiration was reduced (Fig. 4). Drainage was higher at very low EPXMAX values. Some attempt to obtain realistic values for EPXMAX are necessary in any application of the model. In the standard run, interception was 17% of the July precipitation.

Leaf Parameters (Fig. 5, 6, 7, 8, 9)

The maximum leaf area index (ALMAX) had little effect on the water balance at values above $3.5 \text{ cm}^2 \cdot \text{cm}^{-2}$ (Fig. 5). Decrease in leaf area index below 3 caused a marked decrease in transpiration and increase in drainage. Soil evaporation increased a small amount with decrease in leaf area. The formalization of the model was based on the assumption of a uniform evapotranspiration surface (full canopy or litter) and the interpolation to leaf area indices between a full canopy and litter ($\text{LAI} \approx 0.0$) may give poor simulation results. Increase in leaf area index from low (.001) to high (12) values was accompanied with increase in the proportion of water taken up from the first soil layer (A horizon). This reflected the drying of the first layer and rewetting by rainfall with reduced water flux between soil layers as the amount of transpiration increased with increase in leaf area index.

Increase in minimum surface resistance (TMS) to vapor loss caused a decrease in both transpiration and soil evaporation and an increase in drainage (Fig. 6). Change in soil water storage showed little response to change in TMS. There was no effect on interception evaporation. Water uptake from the first soil layer increased with increase in TMS.

Fig. 5. Sensitivity of July water balance components to change in maximum leaf area index of the vegetation (ALMAX).

ORNL-DWG 75-14017

x STANDARD VALUE
 JULY PRECIPITATION = 10.8 cm
 POTENTIAL EVAPORATION = 12.3 cm

Fig. 6. Sensitivity of July water balance components to change in the minimum resistance of the evapotranspiration surface (TMS).

ORNL-DWG 75-14018

x STANDARD DATA
 JULY PRECIPITATION = 10.8 cm
 POTENTIAL EVAPORATION = 12.3 cm

Fig. 7. Sensitivity of July water balance components to change in the maximum resistance of the evapotranspiration surface (RESS).

x STANDARD DATA

ORNL-DWG 75-14019

JULY PRECIPITATION = 10.8 cm

POTENTIAL EVAPORATION = 12.3 cm

Fig. 8. Sensitivity of July water balance components to change in the surface water potential at which surface resistance becomes maximum (PWPS).

x STANDARD DATA

ORNL-DWG 75-14020

JULY PRECIPITATION = 10.8 cm

POTENTIAL EVAPORATION = 12.3 cm

Fig. 9. Sensitivity of July water balance components to change in the exponential power term in the surface resistance equation (POWS).

There was essentially no effect of increase in the maximum surface resistance (RESS) above 50 sec/cm on the monthly water budget (Fig. 7). Below 50 sec/cm soil water storage and soil evaporation increased and drainage decreased. Water uptake from the first soil layer showed a slight increase with increase in RESS.

Soil evaporation and transpiration showed a large decrease with increase in the surface potential for maximum surface resistance (PWPS) (Fig. 8). There was a concomitant increase in drainage and a small change in soil water storage. At water potentials below -30 bars there were minor effects on the monthly water budget. Root water uptake was higher from the first soil layer when the transpiration was lower.

There was a small decrease in transpiration with increase in the exponential power term (POWS) above -0.4 (Fig. 9). Stomata tend to respond to water stress with an almost on-off response at a critical water potential. This is best described by small POWS values eg. < -0.5 . At these low values there was little sensitivity of the model for the case examined.

Stem, Litter and Root Parameters (Fig. 10, 11, 12, 13, 14)

The resistance to water flow in the stem (RSTEM) had a significant influence on the components of the monthly water budget (Fig. 10). Transpiration decreased with increase in RSTEM and this was accompanied by an increase in soil evaporation and drainage. The higher resistance caused less water loss through the vegetation and a higher soil water content and hence higher soil evaporation.

ORNL-DWG 75-14021

x STANDARD DATA
 JULY PRECIPITATION = 10.8 cm
 POTENTIAL EVAPORATION = 12.3 cm

PERCENT WATER UPTAKE FIRST SOIL LAYER

Fig. 10. Sensitivity of July water balance components to change in stem resistance (RSTEM).

ORNL-DWG 75-14022

x STANDARD DATA
 JULY PRECIPITATION = 10.8 cm
 POTENTIAL EVAPORATION = 12.3 cm

PERCENT WATER UPTAKE FIRST SOIL LAYER

Fig. 11. Sensitivity of July water balance components to change in litter resistance (RLIT).

ORNL-DWG 75-14023

x STANDARD DATA

JULY PRECIPITATION = 10.8 cm

POTENTIAL EVAPORATION = 12.3 cm

ARAT (1) ROOTS IN FIRST LAYER

ARAT (2) ROOTS IN SECOND LAYER

Fig. 12. Sensitivity of July water balance components to change in the proportional distribution of roots (ARAT). (The extreme values of ARAT are 0.001 and 0.999 and not 0.0 and 1.0.)

Fig. 13. Sensitivity of July water balance components to change in proportion of root cross sectional area in the first soil layer (AT(1)).

Fig. 14. Sensitivity of July water balance components to change in proportion of root cross sectional area in the second soil layer (AT(2)).

RLIT represented the effect of soil components on limiting the flow of liquid water to the soil surface. A zero value resulted in a large amount of soil evaporation (Fig. 11). There was a decrease in soil evaporation and an increase in transpiration with increase in RLIT. Drainage and soil storage were not much affected by RLIT. In contrast with other parameter effects, the water uptake from the first soil layer increased with increase in transpiration.

The proportion of roots in the first layer relative to the second (ARAT) was varied through a large range with very little effect on the components of the water budget (Fig. 12). The percentage of water taken up from the first layer however increased with increase in the proportion of roots in the first layer. The model shows that 11% of the root water uptake can take place through 0.1% of roots in the first soil layer or 97% can be taken up through 99.9% of roots in the first layer. It should be noted that the extreme values used for ARAT are 0.001 and 0.999 and not 0 and 1 (see Table 1).

An increase in the cross sectional area of roots up to $0.5 \text{ cm}^2/\text{cm}^2$ in the first soil layer AT(1) caused an increase in transpiration (Fig. 13). Drainage and soil evaporation increased as transpiration was reduced. Water uptake from the first soil layer decreased with increase in root cross-sectional area and this followed the general trend of lower uptake from the first soil layer with increase in transpiration. AT(2) was given a much lower standard value than AT(1) and the range of responses was much less than for AT(1) (Fig. 14). There was relatively little effect of change in AT(2) on the components of the water balance.

Root Conductivity and Soil Parameters (Fig. 15, 16, 17, 18)

There is very little information on the root conductivity to water flow and an intuitive hypothesis was used in the model. Root conductivity for the first layer was made. RTCON1 times the soil hydraulic conductivity for that layer. At low RTCON1 values, transpiration was small and drainage was high (Fig. 15). Increase in RTCON1 increased transpiration and decreased both soil evaporation and drainage. Water uptake from the first soil layer was proportionally decreased with higher root conductivity. This agrees with the effects of other factors where higher transpiration rates were accompanied by lower proportional uptake of water from the first layer.

In contrast with RTCON1, there was relatively little effect of RTCON2 on the monthly water balance (Fig. 16). This is probably a consequence of the higher soil hydraulic conductivity in the first soil layer. An interaction study of RTCON and the next factor, SCON would provide further insight into range of sensitivity of these factors. Increase in RTCON2 above 40 induced an increase in transpiration and a decrease in the proportion of water taken up from the first soil layer.

Saturated hydraulic conductivity is used to set the upper limit of the hydraulic conductivities of the soil layers. In the standard soil the saturated values were 150 and 75 cm/day for the first layer and other layers respectively. Order of magnitude increases in hydraulic conductivity (FACTOR) caused an increased in transpiration (Fig. 17). Effects on drainage and soil storage were more complicated. Runoff was generated when the conductivity FACTOR was less than 0.1.

RTCON 2 = 400 FOR ALL RUNS
 x STANDARD DATA
 JULY PRECIPITATION = 10.8 cm
 POTENTIAL EVAPORATION = 12.3 cm

Fig. 15. Sensitivity of July water balance components to change in root conductivity factor in the first soil layer (RTCON1).

RTCON 1 = 20 FOR ALL RUNS
 x STANDARD DATA
 JULY PRECIPITATION = 10.8 cm
 POTENTIAL EVAPORATION = 12.3 cm

Fig. 16. Sensitivity of July water balance components to change in root conductivity factor in the second soil layer (RTCON2).

ORNL-DWG 75-14028

Fig. 17. Sensitivity of July water balance components to change in saturated hydraulic conductivity factor (FACTOR).

ORNL-DWG 75-14029

Fig. 18. Sensitivity of July water balance components to change in soil layer thickness (DL).

Change in soil layer thickness (DL) above 30 cm had negligible effects on the components of the water balance (Fig. 18).

Water Status of Vegetation, Daily Evapotranspiration and Drainage

The evaporation surface showed large diurnal changes in water status and this surface was perhaps the most sensitive to changes in water supply and demand. For this reason some sensitivity comparisons are given for surface water potential, conductance and evapotranspiration rate for several days following a rainfall (i.e., system increasing in stress). A rainfall of 3.1 cm received on 8 July 1953 (ended at 6 pm) was followed by six sunny days. The daily drainage rates for the same period are also presented to assess particularly soil parameter effects on short term model response. Results for the 9th and 14th of July are tabulated below to show the effects of change in parameters on the midday values of surface potential and conductance and daily drainage and evapotranspiration rate.

Slope and Canopy Parameters (Tables 2a, b, c, d)

Surface water potential was lower with increase in inclination for both north (AZIM = 360°) and south (AZIM = 180°) facing slopes (Table 2a). This may seem to contradict normal experience of north facing slopes having less water stress. Surface conductance was lower with increase in inclination while the evapotranspiration rate was higher on steeper slopes. The daily drainage rate was highest at the 60° slope with a south facing aspect (AZIM = 180°) whereas the north facing slopes had drainage rates less than the horizontal surface (INCL = 0°). The solar

TABLE 2a

Surface Water Potential (bars)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
AXIM = 180°							
INCL (degrees)	0*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	30	-19.7	-19.9	-21.7	-24.3	-26.8	-28.2
	45	-20.2	-20.3	-22.1	-24.6	-26.9	-28.3
	60	-21.0	-20.9	-22.3	-24.2	-26.6	-28.1
	75	-22.5	-22.3	-23.5	-25.3	-27.3	-28.6
AZIM = 360°							
INCL (degrees)	30	-19.0	-19.5	-22.2	-25.4	-27.3	-28.5
	45	-19.2	-19.7	-22.4	-25.5	-27.3	-28.6
	60	-21.0	-21.6	-24.7	-26.9	-28.1	-29.2
	75	-24.8	-26.1	-28.6	-29.5	-30.2	-31.0
ALBS	0	-19.6	-20.2	-23.1	-26.0	-27.6	-28.7
	0.06	-19.2	-19.8	-22.5	-25.6	-27.4	-28.6
	0.12*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	0.24	-17.9	-18.4	-20.7	-24.3	-26.8	-28.2
	0.48	-15.8	-16.4	-17.7	-20.4	-25.4	-27.3
	0.75	-13.3	-14.0	-14.2	-14.0	-20.3	-25.5
SDRAG	0.1	-18.5	-19.2	-21.8	-25.0	-27.3	-28.6
	0.4	-18.6	-19.2	-21.8	-25.1	-27.3	-28.6
	0.6*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	0.9	-18.9	-19.5	-22.2	-25.3	-27.1	-28.4
EPXMAX	0.0001	-18.7	-18.9	-20.4	-23.3	-26.5	-28.1
(cm)	0.02	-18.8	-19.2	-21.4	-24.7	-27.0	-28.4
	0.04	-18.8	-19.2	-21.7	-24.9	-27.1	-28.4
	0.063*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	0.08	-18.8	-19.4	-22.1	-25.3	-27.2	-28.5
	0.10	-18.8	-19.4	-22.3	-25.4	-27.3	-28.5

* indicates the standard value.

TABLE 2b

Surface Conductance (sec ⁻¹ cm ⁻¹)		DAYS IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
AZIM = 180°							
INCL	0*	.471	.463	.385	.201	.099	.057
(degrees)	30	.457	.452	.397	.254	.116	.064
	45	.445	.441	.379	.236	.110	.061
	60	.422	.423	.371	.262	.124	.067
	75	.360	.368	.301	.190	.095	.053
AZIM = 360°							
INCL	30	.468	.459	.371	.187	.095	.055
(degrees)	45	.465	.456	.362	.179	.093	.055
	60	.420	.401	.231	.109	.066	.044
	75	.224	.146	.054	.036	.026	.017
ALBS	0	.457	.445	.327	.153	.084	.050
	0.06	.465	.455	.358	.175	.091	.054
	0.12*	.471	.463	.385	.201	.099	.057
	0.24	.481	.476	.430	.257	.115	.065
	0.48	.493	.491	.483	.439	.189	.093
	0.75	.498	.497	.497	.497	.443	.180
SDRAG	0.1	.475	.465	.390	.208	.093	.053
	0.4	.473	.464	.391	.204	.095	.054
	0.6*	.471	.463	.385	.201	.099	.057
	0.9	.469	.461	.371	.192	.100	.059
EPXMAX	0.0001	.472	.470	.438	.313	.128	.067
(cm)	0.02	.471	.465	.406	.229	.105	.059
	0.04	.471	.464	.397	.218	.102	.058
	0.063*	.471	.463	.385	.201	.099	.057
	0.08	.471	.462	.376	.190	.096	.056
	0.10	.471	.462	.371	.184	.095	.055

* indicates the standard value.

TABLE 2c

Evapotranspiration Rate ($\text{cm}^3 \cdot \text{cm}^{-2} \text{ land} \cdot \text{day}^{-1}$)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
AZIM = 180°							
INCL (degrees)	0*	.633	.621	.521	.324	.243	.190
	30	.582	.569	.509	.350	.253	.194
	45	.584	.572	.510	.348	.250	.192
	60	.549	.524	.483	.358	.260	.195
	75	.568	.538	.487	.346	.243	.186
AZIM = 360°							
INCL (degrees)	30	.641	.625	.516	.317	.239	.188
	45	.646	.628	.514	.314	.237	.187
	60	.722	.659	.464	.274	.213	.170
	75	.915	.596	.303	.204	.163	.135
ALBS	0	.661	.636	.502	.301	.230	.182
	0.06	.647	.629	.514	.313	.237	.186
	0.12*	.633	.621	.521	.324	.243	.190
	0.24	.605	.602	.527	.344	.255	.197
	0.48	.543	.556	.515	.387	.291	.218
	0.75	.461	.497	.461	.381	.364	.263
SDRAG	0.1	.582	.610	.554	.353	.255	.196
	0.4	.607	.619	.538	.339	.249	.194
	0.6*	.633	.621	.521	.324	.243	.190
	0.9	.654	.620	.499	.305	.235	.185
EPXMAX (cm)	0.0001	.646	.628	.575	.405	.287	.215
	0.02	.645	.624	.541	.347	.255	.197
	0.04	.645	.623	.534	.337	.250	.194
	0.063*	.633	.621	.521	.324	.243	.190
	0.08	.612	.620	.513	.315	.239	.187
	0.10	.577	.619	.508	.311	.236	.185

* indicates standard value.

TABLE 2d

Drainage Rate cm ³ ·cm ⁻² land·day ⁻¹		DAYS IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
AZIM = 180°							
INCL	0*	.029	.028	.027	.027	.026	.026
(degrees)	30	.031	.031	.030	.029	.029	.028
	45	.031	.030	.030	.029	.029	.028
	60	.033	.032	.032	.031	.030	.030
	75	.030	.029	.029	.028	.028	.028
AZIM = 360°							
INCL	30	.028	.027	.027	.026	.026	.025
(degrees)	45	.028	.027	.027	.026	.026	.025
	60	.023	.023	.022	.022	.022	.021
	75	.015	.015	.014	.014	.014	.014
ALBS	0	.026	.026	.025	.025	.024	.039
	0.06	.027	.027	.026	.026	.025	.025
	0.12*	.029	.028	.027	.027	.026	.026
	0.24	.031	.030	.029	.029	.028	.028
	0.48	.037	.036	.035	.035	.034	.034
	0.75	.049	.047	.046	.046	.045	.045
SDRAG	0.1	.029	.029	.028	.028	.027	.027
	0.4	.029	.028	.028	.027	.027	.026
	0.6*	.029	.028	.027	.027	.026	.026
	0.9	.028	.027	.026	.026	.025	.025
EPXMAX	0.0001	.038	.037	.037	.036	.036	.036
(cm)	0.02	.032	.031	.030	.030	.029	.029
	0.04	.030	.029	.029	.028	.028	.027
	0.063*	.029	.028	.027	.027	.026	.026
	0.08	.027	.027	.026	.026	.025	.025
	0.10	.026	.025	.025	.025	.024	.024

* indicates standard value.

radiation is adjusted to a horizontal surface basis in the model. Thus a 75° slope has 3.86 cm^2 of slope surface and a horizontal projection of 1 cm^2 . The increase in slope surface area with increase in inclination increases the radiation on the projected horizontal surface.

Increase in albedo (ALBS) caused an increase in both surface water potential and conductance and a decrease in daily evapotranspiration rate. The reduced energy load on the vegetation with higher albedo values reduced water loss from the soil and allowed a higher water potential in the vegetation. The reduction in evapotranspiration with increase in ALBS was accompanied by an increase in drainage rate.

The boundary layer resistance to heat and vapor loss from the vegetation is reduced with lower wind speeds that occur with higher values for the canopy drag coefficient (SDRAG). A large increase in the drag coefficient caused a small decrease in both surface potential and conductance and an increase in evapotranspiration rate and a slight decrease in drainage rate.

Increase in interception storage maximum (EPXMAX) had almost no effect on surface water potential or conductance. Evapotranspiration rate was reduced with increase in interception storage above 0.06 cm. Drainage rates were considerably higher with lower values in EPXMAX. This trend was maintained through the six day period.

Leaf Parameters (Tables 3a, b, c, d)

Increase in leaf area index (ALMAX) was associated with increases in both surface water potential and conductance although there were less effects above a leaf area index of 6. Evapotranspiration rate

TABLE 3a

Surface Water Potential (bars)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
ALMAX ($\text{cm}^2 \cdot \text{cm}^{-2}$)	0.01	-30.6	-30.2	-30.3	-30.4	-30.4	-30.9
	0.5	-28.4	-28.0	-28.2	-28.2	-28.3	-28.8
	1.0	-26.1	-25.8	-25.9	-25.9	-26.1	-26.9
	2.0	-22.8	-22.6	-23.2	-23.6	-25.1	-27.1
	4.0	-19.5	-19.8	-21.7	-24.2	-26.7	-28.2
	6.0*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	8.0	-18.7	-19.3	-22.4	-25.7	-27.4	-28.6
	12.0	-18.8	-19.6	-23.1	-26.2	-27.7	-28.8
TMS ($\text{sec} \cdot \text{cm}^{-1}$)	0	-23.6	-24.5	-26.8	-27.7	-28.5	-29.3
	1	-21.9	-22.7	-25.1	-26.9	-28.0	-29.0
	2*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	4	-12.7	-12.1	-12.8	-13.2	-18.2	-25.8
	5	-10.8	-10.2	-10.5	-10.5	-12.3	-19.5
	10	- 6.24	- 5.61	- 5.75	- 5.60	- 5.95	- 7.30
	15	- 4.40	- 3.90	- 3.98	- 3.90	- 4.13	- 5.02
RESS ($\text{sec} \cdot \text{cm}^{-1}$)	10	-20.2	-27.6	-33.5	-47.0	-81.8	-181.
	25	-19.4	-20.6	-26.9	-30.7	-32.3	-33.6
	50	-19.3	-20.2	-24.8	-28.8	-30.6	-31.9
	150	-19.0	-19.7	-22.8	-26.3	-28.2	-29.5
	250*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	500	-18.4	-18.8	-20.8	-23.6	-25.8	-27.1
PWPS (bars)	- 5	- 1.57	- 1.45	- 1.47	- 1.47	- 1.52	- 1.70
	-10	- 4.22	- 4.02	- 4.06	- 4.03	- 4.13	- 4.45
	-20	-11.1	-10.9	-11.1	-11.1	-11.9	-13.4
	-30	-17.4	-17.5	-18.8	-20.8	-23.0	-24.4
	-34*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	-40	-19.4	-20.4	-26.4	-31.3	-33.2	-34.5
	-60	-19.5	-21.0	-33.8	-51.0	-53.1	-54.5
POWS	-.3	-15.5	-15.4	-16.3	-18.0	-21.6	-24.1
	-.4	-17.7	-17.9	-19.7	-22.6	-25.3	-27.0
	-.5*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	-.6	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	-.8	-19.2	-20.0	-23.6	-26.8	-28.4	-29.4
		-19.4	-20.4	-25.6	-28.7	-29.8	-30.6

* indicates standard value.

TABLE 3b

Surface Conductance (sec·cm ⁻¹)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
ALMAX (cm ² ·cm ⁻²)	0.01	.021	.026	.024	.024	.023	.019
	0.5	.058	.069	.065	.065	.063	.050
	1.0	.147	.166	.157	.160	.148	.111
	2.0	.341	.351	.322	.300	.203	.101
	4.0	.459	.453	.396	.262	.121	.065
	6.0*	.471	.463	.385	.201	.099	.057
	8.0	.472	.463	.361	.167	.089	.053
	12.0	.471	.458	.326	.143	.079	.049
TMS (sec·cm ⁻¹)	0	.732	.459	.149	.094	.064	.041
	1	.632	.539	.255	.124	.075	.047
	2*	.471	.463	.385	.201	.099	.057
	4	.250	.250	.250	.250	.245	.124
	5	.200	.200	.200	.200	.200	.193
	10	.100	.100	.100	.100	.100	.100
	15	.067	.067	.067	.067	.067	.067
RESS (sec·cm ⁻¹)	10	.498	.429	.120	.100	.100	.100
	25	.496	.493	.378	.157	.085	.049
	50	.493	.488	.401	.179	.092	.054
	150	.480	.473	.393	.193	.097	.057
	250*	.471	.463	.385	.201	.099	.057
	500	.454	.445	.372	.208	.099	.057
PWPS (bars)	- 5	.021	.023	.022	.023	.022	.020
	-10	.063	.069	.068	.069	.066	.057
	-20	.206	.217	.207	.203	.159	.091
	-30	.409	.403	.345	.221	.104	.059
	-34*	.471	.463	.385	.201	.099	.057
	-40	.498	.497	.440	.191	.097	.056
	-60	.500	.500	.500	.213	.103	.056
POWS	-.3	.338	.340	.309	.246	.125	.068
	-.4	.423	.416	.357	.216	.104	.059
	-.5*	.471	.463	.385	.201	.099	.057
	-.6	.491	.487	.405	.188	.096	.056
	-.8	.500	.499	.435	.183	.093	.054

* indicates standard value.

TABLE 3c

Evapotranspiration Rate ($\text{cm}^3 \cdot \text{cm}^{-2} \text{ land} \cdot \text{day}^{-1}$)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
ALMAX ($\text{cm}^2 \cdot \text{cm}^{-2}$)	0.01	.059	.061	.061	.059	.061	.062
	0.5	.137	.139	.136	.131	.136	.137
	1.0	.285	.280	.272	.254	.261	.255
	2.0	.478	.463	.436	.372	.329	.252
	4.0	.592	.579	.516	.359	.263	.200
	6.0*	.633	.621	.521	.324	.243	.190
	8.0	.658	.644	.512	.303	.234	.185
	12.0	.685	.667	.494	.283	.226	.180
TMS ($\text{sec} \cdot \text{cm}^{-1}$)	0	.929	.767	.383	.232	.185	.151
	1	.778	.718	.459	.266	.211	.168
	2*	.633	.621	.521	.324	.243	.190
	4	.425	.406	.396	.356	.371	.289
	5	.363	.342	.334	.304	.329	.362
	10	.210	.191	.188	.176	.191	.227
	15	.148	.133	.131	.124	.134	.161
RESS ($\text{sec} \cdot \text{cm}^{-1}$)	10	.678	.587	.321	.253	.248	.288
	25	.660	.664	.517	.303	.238	.195
	50	.651	.649	.530	.314	.242	.193
	150	.639	.630	.525	.320	.242	.190
	250*	.633	.621	.521	.324	.243	.190
	500	.624	.608	.516	.329	.245	.190
PWPS (bars)	- 5	.056	.053	.051	.049	.053	.059
	-10	.163	.158	.153	.144	.155	.163
	-20	.424	.412	.388	.339	.320	.255
	-30	.600	.582	.505	.341	.250	.193
	-34*	.633	.621	.521	.324	.243	.190
	-40	.649	.649	.541	.317	.243	.190
	-60	.649	.653	.592	.337	.255	.191
POWS	-.3	.549	.532	.482	.363	.276	.209
	-.4	.608	.591	.511	.338	.251	.195
	-.5*	.633	.621	.521	.324	.243	.190
	-.6	.644	.637	.527	.316	.239	.188
	-.8	.649	.650	.536	.312	.238	.186

* indicates standard value.

TABLE 3d

Drainage Rate ($\text{cm}^3 \cdot \text{cm}^{-2} \text{ land} \cdot \text{day}^{-1}$)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
ALMAX ($\text{cm}^2 \cdot \text{cm}^{-2}$)	0.01	.126	.170	.210	.228	.229	.220
	0.5	.102	.113	.129	.139	.143	.142
	1.0	.068	.067	.066	.067	.067	.067
	2.0	.037	.036	.035	.035	.034	.034
	4.0	.029	.029	.028	.027	.027	.027
	6.0*	.029	.028	.027	.027	.026	.026
	8.0	.028	.028	.027	.027	.026	.026
	12.0	.028	.028	.027	.027	.026	.026
TMS ($\text{sec} \cdot \text{cm}^{-1}$)	0	.021	.021	.020	.020	.020	.019
	1	.024	.023	.023	.023	.022	.022
	2*	.029	.028	.027	.027	.026	.026
	4	.041	.040	.039	.038	.037	.037
	5	.049	.047	.046	.045	.045	.044
	10	.083	.082	.082	.084	.085	.085
	15	.099	.105	.115	.123	.127	.127
RESS ($\text{sec} \cdot \text{cm}^{-1}$)	10	.012	.012	.012	.012	.011	.011
	25	.023	.023	.022	.022	.022	.021
	50	.026	.025	.025	.024	.024	.023
	150	.028	.027	.026	.026	.026	.025
	250*	.029	.028	.027	.027	.026	.026
	500	.029	.029	.028	.028	.027	.027
PWPS (bars)	- 5	.129	.178	.219	.238	.237	.227
	-10	.097	.104	.113	.121	.125	.125
	-20	.050	.048	.047	.047	.046	.046
	-30	.031	.031	.030	.029	.029	.029
	-34*	.029	.028	.027	.027	.026	.026
	-40	.025	.025	.024	.024	.023	.023
	-60	.020	.020	.019	.019	.019	.018
POWS	-.3	.034	.033	.033	.032	.031	.031
	-.4	.030	.029	.029	.028	.028	.027
	-.5*	.029	.028	.027	.027	.026	.026
	-.6	.027	.027	.026	.026	.025	.025
	-.8	.027	.026	.026	.025	.025	.024

* indicates standard value.

increased and drainage rate decreased with increase in leaf area index. A large water loss early in the drying period induced smaller evapotranspiration rates later in the period, however the drainage rate differences increased through the six day period.

An increase in minimum surface resistance (TMS) caused an increase in surface water potential and a decrease in surface conductance. Evapotranspiration rate was greatly reduced with higher minimum resistance and the accompanying drainage rate increased. However greater water loss early in the drying period induced stress later in the period and there were less effects of TMS values on evapotranspiration later in the period. The drainage rate effects were maintained through the drying period.

Higher values of maximum surface resistance (RESS) caused lower surface potential and conductance values. Evapotranspiration was reduced and drainage was slightly increased. These trends were not consistent through the drying period.

The leaf water potential at which stomatal resistance becomes a maximum (PWPS) is an important plant characteristic that is being increasingly documented in the literature (Ritchie and Hinckley 1975). A decrease in this term was associated with a decrease in surface water potential, increase in conductance and initially higher evapotranspiration rates. A value of PWPS of -20 bars had the highest evapotranspiration rate on the 14th day in July. Drainage rate was decreased with decrease in PWPS.

A decrease in the exponential power term (POWS) in the surface resistance-potential equation was accompanied by a decrease in surface water potential and increases in conductance and daily evapotranspiration rate in the first part of the drying period. Conductance and evapotranspiration rate were higher at higher POWS values after the 11th day of July. Drainage rates were higher at higher POWS values.

Stem, Litter and Root Parameters (Tables 4a, b, c, d)

RSTEM represents the resistance of xylem vessels in the roots, trunk, branches and leaves to liquid water flow. It is generally considered that this is not the main plant resistance to water flow (Newman 1972). Nevertheless the model indicated that an increase in RSTEM induced a decrease in surface water potential, conductance and evapotranspiration rate in the first part of the drying period. There was much less effect of RSTEM on the 14th day in July. Drainage rates were higher at higher RSTEM values and these higher rates were maintained through the six day period.

An increase in RLIT had very little effect on surface conductance, evapotranspiration rate or drainage rate although in the first part of the drying period surface potential was decreased. Figure 11 shows that there was an increase in transpiration and a decrease in soil evaporation with increase in RLIT. These effects compensated to give about the same evapotranspiration rate in the drying period.

The proportional distribution of roots (ARAT) between the two upper soil layers had a relatively small effect on the surface water relations. This analysis suggests that the soil-plant system can make

TABLE 4a

Surface Water Potential (bars)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
RSTEM (days)	50	- 0.66	- 2.02	-10.2	-25.5	-27.5	-28.7
	500	- 2.43	- 3.75	-11.9	-25.5	-27.5	-28.7
	5000*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	25000	-27.1	-26.8	-26.8	-26.7	-26.8	-27.4
	50000	-28.4	-28.1	-28.1	-28.0	-28.1	-28.6
RLIT (days)	0	- 0.53	- 2.32	-13.7	-25.6	-27.3	-28.6
	300	- 0.96	- 2.68	-13.8	-25.6	-27.3	-28.6
	3000	- 4.12	- 5.39	-14.7	-25.6	-27.3	-28.6
	30000	-14.1	-14.8	-19.7	-25.4	-27.3	-28.6
	300000*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	900000	-19.2	-19.7	-22.1	-25.1	-27.2	-28.6
ARAT	0.001	-19.9	-21.9	-23.8	-25.0	-26.4	-27.6
	0.1	-19.0	-19.8	-22.1	-24.2	-26.5	-28.2
	0.4	-18.8	-19.4	-22.0	-24.9	-27.1	-28.4
	0.6*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	0.9	-18.8	-19.3	-22.0	-25.2	-27.3	-28.5
	0.999	-18.8	-19.3	-22.4	-25.9	-27.5	-28.6
AT(1) (cm ² ·cm ⁻²)	0.001	-23.3	-25.7	-26.9	-27.6	-28.4	-29.3
	0.01	-19.9	-22.4	-25.2	-26.7	-28.0	-29.2
	0.2*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	0.5	-18.9	-19.5	-21.8	-24.3	-26.5	-28.0
	0.7	-18.9	-19.6	-21.8	-24.2	-26.4	-27.9
	0.9	-19.0	-19.7	-21.9	-24.1	-26.3	-27.9
AT(2) (cm ² ·cm ⁻²)	0.001	-18.8	-19.4	-22.5	-25.9	-27.5	-28.6
	0.01*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	0.2	-18.8	-19.3	-21.8	-25.0	-27.1	-28.5
	0.5	-18.8	-19.3	-22.1	-25.4	-27.2	-28.5
	0.7	-18.8	-19.4	-22.2	-25.5	-27.3	-28.5
	0.9	-18.8	-19.4	-22.3	-25.6	-27.3	-28.5

* indicates standard value.

TABLE 4b

Surface Conductance ($\text{sec} \cdot \text{cm}^{-1}$)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
RSTEM (days)	50	.500	.500	.500	.182	.087	.051
	500	.500	.500	.500	.182	.088	.052
	5000*	.471	.463	.385	.201	.099	.057
	25000	.103	.115	.114	.119	.112	.090
	50000	.060	.068	.071	.069	.066	.054
RLIT (days)	0	.500	.500	.498	.174	.093	.054
	300	.500	.500	.498	.174	.093	.054
	3000	.500	.500	.496	.175	.093	.054
	30000	.497	.496	.456	.185	.095	.054
	300000*	.471	.463	.385	.201	.099	.057
	900000	.465	.456	.380	.204	.096	.055
ARAT	0.001	.451	.388	.283	.211	.135	.081
	0.1	.468	.453	.380	.259	.128	.065
	0.4	.471	.462	.385	.215	.102	.058
	0.6*	.471	.463	.385	.201	.099	.057
	0.9	.471	.464	.382	.184	.095	.056
	0.999	.471	.464	.364	.157	.087	.053
AT(1) ($\text{cm}^2 \cdot \text{cm}^{-2}$)	0.001	.315	.172	.108	.082	.059	.040
	0.01	.452	.363	.199	.119	.068	.040
	0.2*	.471	.463	.385	.201	.099	.057
	0.5	.470	.460	.392	.253	.129	.070
	0.7	.469	.458	.390	.263	.135	.073
	0.9	.468	.456	.386	.268	.140	.073
AT(2) ($\text{cm}^2 \cdot \text{cm}^{-2}$)	0.001	.471	.462	.360	.158	.088	.053
	0.01*	.471	.463	.385	.201	.099	.057
	0.2	.471	.463	.391	.211	.100	.057
	0.5	.471	.462	.377	.188	.096	.056
	0.7	.471	.462	.372	.181	.095	.056
	0.9	.471	.462	.369	.176	.093	.056

* indicates standard value.

TABLE 4c

Evapotranspiration Rate ($\text{cm}^3 \cdot \text{cm}^{-2} \cdot \text{land} \cdot \text{day}^{-1}$)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
RSTEM (days)	50	.648	.651	.597	.304	.226	.175
	500	.649	.651	.591	.304	.227	.176
	5000*	.633	.621	.521	.324	.243	.190
	25000	.276	.279	.268	.249	.270	.268
	50000	.177	.184	.178	.168	.181	.182
RLIT (days)	0	.650	.653	.555	.298	.232	.181
	300	.650	.653	.555	.298	.232	.181
	3000	.650	.653	.558	.299	.232	.181
	30000	.648	.649	.548	.310	.237	.184
	300000*	.633	.621	.521	.324	.243	.190
	900000	.630	.617	.520	.326	.241	.187
ARAT	0.001	.619	.561	.459	.346	.302	.248
	0.1	.631	.614	.533	.379	.287	.213
	0.4	.633	.620	.526	.337	.251	.193
	0.6*	.633	.621	.521	.324	.243	.190
	0.9	.634	.622	.515	.311	.237	.188
	0.999	.634	.621	.491	.283	.224	.181
AT(1) ($\text{cm}^2 \cdot \text{cm}^{-2}$)	0.001	.509	.353	.254	.188	.167	.142
	0.01	.618	.528	.367	.240	.188	.144
	0.2*	.633	.621	.521	.324	.243	.190
	0.5	.633	.619	.537	.372	.289	.220
	0.7	.632	.617	.538	.382	.299	.227
	0.9	.632	.616	.538	.387	.304	.229
AT(2) ($\text{cm}^2 \cdot \text{cm}^{-2}$)	0.001	.634	.619	.491	.287	.225	.181
	0.01*	.633	.621	.521	.324	.243	.190
	0.2	.633	.622	.529	.332	.246	.191
	0.5	.633	.620	.512	.314	.239	.189
	0.7	.633	.620	.507	.308	.236	.187
	0.9	.633	.620	.503	.304	.234	.186

* indicates standard value.

TABLE 4d

Drainage Rate ($\text{cm}^3 \cdot \text{cm}^{-2} \text{ land} \cdot \text{day}^{-1}$)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
RSTEM (days)	50	.026	.025	.025	.024	.024	.023
	500	.026	.025	.025	.024	.024	.023
	5000*	.029	.028	.027	.027	.026	.026
	25000	.068	.066	.065	.064	.064	.064
	50000	.093	.095	.100	.105	.108	.108
RLIT (days)	0	.026	.026	.025	.025	.024	.024
	300	.026	.026	.025	.025	.024	.024
	3000	.026	.026	.025	.025	.024	.024
	30000	.026	.026	.025	.025	.024	.024
	300000*	.029	.028	.027	.027	.026	.026
	900000	.029	.028	.028	.027	.027	.026
ARAT	0.001	.022	.022	.021	.021	.020	.020
	0.1	.021	.021	.020	.020	.020	.019
	0.4	.027	.026	.026	.025	.025	.024
	0.6*	.029	.028	.027	.027	.026	.026
	0.9	.030	.029	.029	.028	.028	.027
	0.999	.034	.034	.033	.032	.032	.031
AT(1) ($\text{cm}^2 \cdot \text{cm}^{-2}$)	0.001	.081	.082	.086	.090	.092	.092
	0.01	.059	.058	.058	.058	.059	.059
	0.2*	.029	.028	.027	.027	.026	.026
	0.5	.019	.018	.018	.018	.017	.017
	0.7	.017	.017	.016	.016	.016	.016
	0.9	.016	.016	.016	.016	.015	.015
AT(2) ($\text{cm}^2 \cdot \text{cm}^{-2}$)	0.001	.034	.033	.033	.032	.031	.031
	0.01*	.029	.028	.027	.027	.026	.026
	0.2	.027	.027	.026	.026	.025	.025
	0.5	.030	.029	.029	.028	.028	.027
	0.7	.031	.030	.029	.029	.028	.028
	0.9	.031	.031	.030	.029	.029	.029

* indicates standard value.

internal compensations to satisfy the evaporative demand of the atmosphere. The evapotranspiration was largely determined by the atmospheric conditions and not by the soil water availability in the period from 9 to 14 July. The overall water balance for July showed small changes with change in root distribution (Fig. 12). There was a slightly higher drainage rate at higher ARAT values in the first soil layer.

Changes in the cross sectional area of roots in the first (AT(1)) and second soil layer (AT(2)) had relatively little effect on the surface water relations. Higher AT(1) values had higher evapotranspiration rates and conductances and lower drainage rates which were probably induced by the low standard value for AT(2). Conversely the high standard value for AT(1) dominated any effects of change in AT(2).

Root Conductivity and Soil Parameters (Tables 5a, b, c, d)

An increase in the root conductivity factor for the first soil layer (RTCON1) was associated with increases in surface water potential, conductance and daily evapotranspiration rate and decreases in drainage rate. The model showed almost no response to RTCON2 except for drainage rate which was slightly reduced with increase in RTCON2. The July water balance showed a similar sensitivity to these parameters.

Increase in the saturated hydraulic conductivity factor (FACTOR) of each of the soil layers was accompanied by corresponding increases in the unsaturated hydraulic conductivity values. Nevertheless there were very little responses of surface water relations to changes in FACTOR. Drainage rate was highest with the standard conductivity factor. Lower FACTOR values reduced drainage rates whereas the highest

TABLE 5a

Surface Water Potential (bars)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
RTCON1	0.001	-29.7	-29.9	-30.1	-30.2	-30.4	-30.8
	0.01	-26.9	-28.0	-28.6	-28.9	-29.3	-30.0
	0.1	-23.3	-25.7	-26.9	-27.6	-28.4	-29.3
	1.0	-19.9	-22.4	-25.1	-26.6	-28.0	-29.2
	20*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	100	-18.8	-19.2	-21.6	-24.4	-26.3	-27.9
	1000	-18.8	-19.2	-21.6	-23.9	-26.0	-27.8
RTCON2	0.001	-18.8	-19.3	-22.5	-26.1	-27.6	-28.7
	0.01	-18.8	-19.3	-22.5	-26.1	-27.6	-28.7
	0.1	-18.8	-19.3	-22.5	-26.1	-27.6	-28.7
	1.0	-18.8	-19.3	-22.5	-26.1	-27.6	-28.7
	40	-18.8	-19.4	-22.5	-25.9	-27.5	-28.6
	400*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	1000	-18.8	-19.3	-21.6	-24.8	-27.1	-28.4
FACTOR	x 0.01	-18.9	-20.4	-23.7	-25.4	-27.0	-28.4
	x 0.1	-18.8	-19.9	-22.6	-24.8	-26.9	-28.7
	x 1.0*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	x 10.0	-18.9	-19.4	-22.7	-24.6	-26.6	-28.2
DL (cm)	30	-18.7	-19.0	-21.0	-24.7	-27.2	-28.5
	60*	-18.8	-19.3	-22.0	-25.2	-27.2	-28.5
	120	-19.0	-20.4	-24.5	-26.5	-27.6	-28.5
	240	-19.1	-21.0	-25.3	-26.9	-27.7	-28.5

* indicates standard value.

TABLE 5b

Surface Conductance (sec·cm ⁻¹)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
RTCON1	0.001	.033	.030	.027	.026	.024	.019
	0.01	.108	.070	.053	.046	.039	.029
	0.1	.315	.172	.108	.082	.059	.040
	1.0	.452	.366	.203	.122	.070	.041
	20*	.471	.463	.385	.201	.099	.057
	100	.471	.465	.398	.249	.135	.072
	1000	.471	.464	.399	.280	.152	.077
RTCON2	0.001	.471	.462	.357	.146	.081	.051
	0.01	.471	.462	.357	.146	.081	.051
	0.1	.471	.462	.357	.146	.081	.051
	1.0	.471	.462	.357	.147	.081	.051
	40	.471	.462	.360	.158	.088	.053
	400*	.471	.462	.385	.201	.099	.057
	1000	.471	.464	.400	.226	.103	.058
FACTOR	x 0.01	.469	.440	.290	.184	.104	.058
	x 0.1	.471	.451	.352	.223	.108	.051
	x 1.0*	.471	.463	.385	.201	.099	.057
	x 10.0	.470	.462	.346	.235	.123	.065
DL (cm)	30	.472	.469	.421	.228	.098	.056
	60*	.471	.463	.385	.201	.099	.057
	120	.468	.440	.244	.129	.084	.056
	240	.467	.422	.194	.111	.078	.055

* indicates standard value.

TABLE 5c

Evapotranspiration Rate ($\text{cm}^3 \cdot \text{cm}^{-2} \text{ land} \cdot \text{day}^{-1}$)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
RTCON1	0.001	.105	.089	.080	.074	.074	.074
	0.01	.284	.191	.147	.121	.116	.107
	0.1	.509	.353	.254	.188	.167	.142
	1.0	.618	.531	.372	.244	.191	.146
	20*	.633	.621	.521	.324	.243	.190
	100	.634	.623	.537	.371	.296	.224
	1000	.634	.622	.543	.397	.318	.234
RTCON2	0.001	.634	.619	.484	.272	.213	.174
	0.01	.634	.619	.484	.272	.213	.174
	0.1	.634	.619	.484	.272	.213	.174
	1.0	.634	.619	.484	.273	.213	.174
	40	.634	.619	.491	.287	.225	.181
	400*	.633	.621	.521	.324	.243	.190
	1000	.634	.623	.539	.344	.251	.192
FACTOR	x 0.01	.632	.597	.460	.318	.255	.193
	x 0.1	.633	.610	.509	.350	.258	.177
	x 1.0*	.633	.621	.521	.324	.243	.190
	x 10.0	.633	.617	.496	.355	.278	.206
DL (cm)	30	.634	.627	.555	.344	.243	.186
	60*	.633	.621	.521	.324	.243	.190
	120	.631	.593	.403	.253	.217	.186
	240	.630	.570	.356	.232	.208	.185

* indicates standard value.

TABLE 5d

Drainage Rate (cm ³ ·cm ⁻² land·day ⁻¹)		DAY IN JULY					
PARAMETER	VALUE	9	10	11	12	13	14
RTCON1	0.001	.120	.157	.192	.209	.211	.204
	0.01	.102	.119	.138	.148	.152	.149
	0.1	.080	.082	.086	.090	.092	.092
	1.0	.058	.057	.057	.057	.058	.058
	20*	.029	.028	.027	.027	.026	.026
	100	.017	.017	.017	.016	.016	.016
	1000	.013	.013	.013	.013	.013	.012
RTCON2	0.001	.037	.036	.035	.034	.034	.033
	0.01	.037	.036	.035	.034	.034	.033
	0.1	.037	.036	.035	.034	.034	.033
	1.0	.037	.036	.035	.034	.034	.033
	40	.034	.033	.033	.032	.032	.031
	400*	.029	.028	.027	.027	.026	.026
	1000	.026	.025	.025	.024	.024	.023
FACTOR	x 0.01	.000	.000	.000	.000	.000	.000
	x 0.1	.006	.006	.006	.006	.006	.006
	x 1.0*	.029	.028	.027	.027	.026	.026
	x 10.0	.011	.011	.011	.012	.013	.013
DL (cm)	30	.012	.012	.013	.014	.014	.014
	60*	.029	.028	.027	.027	.026	.026
	120	.029	.029	.029	.029	.029	.029
	240	.032	.032	.032	.032	.032	.032

* indicates standard value.

FACTOR value caused the soil drainage to respond very quickly to storm events thus reducing the drainage rate soon after the precipitation.

Change in thickness of the soil layers (DL) below the first layer had almost no effects on the surface water relations. There was almost no effect on evapotranspiration rate, however there was an increase in drainage rate with increase in soil layer thickness. Nevertheless there was only a small difference between the drainage from the 60 cm and 240 cm layers.

DISCUSSION

The PROSPER model of the soil-plant system has negative feedback control mechanisms so that a period of high water loss induces a decrease in water supply and reduces the subsequent rates of water loss even though there may be high evaporative demand. Both stomatal closure in plants under water stress and the large decrease in soil hydraulic conductivity with decrease in soil water content provide two important negative feedback controls. The Prosper model has self-correcting properties that are introduced by these negative feedback controls and these are apparent in the tabulated sensitivity data of surface water relations and daily evapotranspiration rates. The daily drainage rates presented for the six sunny day drying period often showed increases with time, however if the data were compared for a longer period the negative feedback due to soil hydraulic properties would become apparent. The drainage responses to the July 8th rainfall are due to the buffering capacity of the 2.7 m of soil above the drainage depth. In the longer term, the water balance differences between parameter values tend to be

reduced. An examination of the overall results reported here suggest that the parameters fall into four subjective types based on the sensitivity of the July water balance components and the shorter term water relations of the vegetation and soil. These four types and associated parameters are

- I Model sensitive in both short and long term (in approximate order of decreasing sensitivity).
ALMAX, PWPS, RECON1, RLIT, TMS, RSTEM, AT(1), ALBS, ARAT
- II Model sensitive on short term but less sensitive in long term (in approximate order of decreasing sensitivity).
POWS, RESS, AZIM, INCL
- III Model insensitive in short term but sensitive in long term
EPXMAX
- IV Model insensitive overall (or slightly sensitive)
SDRAG, AT(2), RTCON2, FACTOR, DL

The subjective* basis for these four types (Table 6) was visual examination of the data in Figures 1-18 and Tables 2-5 and this was sufficient to develop some discussion of parameter sensitivity. Application of the PROSPER model requires that the parameters in class I be known with accuracy. (These parameters are subject to the "garbage in, garbage out" phenomenon!) Data on leaf area index (ALMAX), minimum stomatal resistance (TMS) and the leaf water potential at which stomatal resistance becomes maximum (PWPS) are becoming increasingly available

*A subjective classification was used so that the project could be completed. A more objective statistical analysis could be made from the data in the tables and figures.

Table 6. Subjective arrangement of parameters into four types based on the sensitivity of the monthly water balance, midday plant water status and daily evapotranspiration and drainage rate to change in parameter value.

Subjective Type	Parameter	Monthly Water Balance	Daily Rate		Midday	
			Evapotranspiration	Drainage	Water Potential	Conductance
I	ALMAX	*****	*****	*****	*****	*****
	PWPS	*****	*****	*****	*****	*****
	RTCON1	*****	***	*****	***	*****
	RLIT	****	*	*	****	*
	TMS	***	*****	****	****	*****
	RSTEM	***	*****	*****	*****	*****
	AT(1)	**	**	*****	**	*
	ALBS	**	***	**	**	*
	ARAT	*	*	**	*	*
II	POWS	*	**	*	**	***
	INCL	*	**	**	**	***
	AZIM	*	**	**	*	**
	RESS	*	**	**	**	*
III	EPXMAX	***	*	*	0	0
IV	SDRAG	0	*	0	0	*
	DL	*	0	**	*	*
	RTCON2	*	0	*	0	0
	FACTOR	*	0	**	0	0
	AT(2)	0	0	*	0	0

[5* highly sensitive → * low sensitivity; 0 almost no sensitivity]

in field studies of soil-plant water relations (Ritchie and Hinckley 1975; Federer 1976). The root conductivity and stem resistance terms (RTCON1, RSTEM) are less likely to be well characterized. Newman (1972) has highlighted the importance of root resistance (reciprocal of conductivity) as one of the main resistances to water flow in the soil-plant system. There is need to modify the PROSPER model structure to include more recent information on this root resistance to water flow. Several studies have shown non-Darcy water flow in plants with the root resistance decreasing with increase in transpiration rate (Newman 1972). The model gives the opposite response of an increase in root resistance with increase in transpiration rate (i.e., soil drying out). Water conduction in the xylem seems to be dependent on the hydrostatic pressure gradient and some estimates of the stem resistance have been made for several species (Peel 1965, Newman 1972). The litter resistance (RLIT) is usually adjusted in model applications such that the value of annual or seasonal soil evaporation is intuitively reasonable. Originally RLIT was not included in the daily model reported by Goldstein and Mankin (1972), nevertheless the evapotranspiration rates were reasonable. This is shown in Figure 11 where the sum of soil evaporation and transpiration is almost independent of the value of RLIT. The root density factor (AT(1)) for the first soil layer and the proportional distribution of roots between two root zone layers (ARAT) can influence the model results although ARAT has a minor influence in this study. A few data may be useful for deriving suitable estimates of PROSPER root parameters. Other applications with the model have suggested that the code needs

deeper root representation to more adequately describe field soil-plant systems (Luxmoore et al. 1976a, Luxmoore et al. 1976b). Cowan's model of water flow in the soil-plant system (Cowan 1965) has shown that low root densities are capable of supplying transpiration demand. There are interaction effects between RTCON1 and RTCON2 and AT(1) and AT(2) in PROSPER that have not been investigated here. This study shows results that are dominated by values of RTCON1 and AT(1). Lower standard values for these parameters would increase the model sensitivity to RTCON2 and AT(2). The albedo of vegetation is fairly well characterized for a range of types (Geiger 1957) and normally a value between 0.15 and 0.22 would be suitable for vegetation. The model does not account for changes in albedo during the day. Vegetation has a high reflectivity (high albedo) at low sun angles but since the insolation is small at this time, the model slightly overestimates the radiation reaching the canopy.

The parameters of type II exhibit the negative feedback characteristic whereby short term responses to change in parameter value dampen long term responses. Two leaf characteristics (POWS, RESS) and two slope characteristics (AZIM, INCL) of this sensitivity type can often be readily obtained or estimated. If the estimates are poor the simulation results will be more accurate in the long term than the short term.

The maximum interception storage (EPXMAX) can show short term effects on midday water relations during rainfall, however in the sunny periods there are only minor effects on water relations. The long term

effect of EPXMAX shows up in the actual interception evaporation. Values of EPXMAX are usually chosen such that the seasonal interception evaporation matches measurement or empirical functions (e.g., Helvey and Patrick 1965).

The parameters of type IV are the soil depth (DL) and hydraulic conductivity characteristics, the canopy wind drag coefficient and two root properties of the second soil layer (RTCON2, AT(2)). The model does not require accurate estimates of wind speed since wind has very little influence on the simulation results. The low sensitivity of the model to soil properties is informative and deceptive. The soil hydraulic properties determine drainage rates and simulation of processes in which drainage rates are important (e.g., short term water balance, solute movement) require accurate input values of soil hydraulic properties. The soil system has been greatly simplified in PROSPER. The soil layers are usually 30 to 60 cm thick in model applications and the soil water is considered to be uniform through each of these layers. Hysteresis in wetting and drying of soil is well known (Slatyer 1967) but has not been included in PROSPER. Omission of hysteresis probably reduces the accuracy of PROSPER forecasts of short term (hourly-daily) soil water status, however, negative feedback increases the accuracy of larger term (daily-weekly) water status estimates.

These sensitivity analyses have relevance to field studies of soil-plant water relations and suggest that estimation of the root and stem resistance to water flow are important in the characterization of short and long term water relations. Reciprocally, field studies have

shown that vegetation is elastic and undergoes shrink-swell changes during a daily cycle (Kozlowski 1968). This is not included in PROSPER. Building this water capacity aspect into the model may not increase our understanding of water relations per se, however the coupling of other plant process models (e.g., growth, solute uptake) with PROSPER may reveal important diurnal interactions of plant processes if shrink-swell properties were included for the vegetation.

Sensitivity analyses provide a useful reference when new applications are being undertaken. These tests have provided a basis for confidence in the model's utility to a diverse range of applications. The stability and reliable performance of the model over a wide range of parameter values suggests that the model applications could be attempted for most forest or agricultural systems on many soil types in diverse landscape situations.

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APPENDIX

Input data set used for the standard sensitivity simulation.
The format is described in the documentation of the Terrestrial
Ecosystem Hydrology Model (Huff et al. 1976).

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LAND SURFACE SIMULATION

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2 DEW DAILY

D	53	51	66.96	70.60	72.18	76.92	73.46	69.40	67.21	68.63	58.72	50.75	54.09
D	53	52	57.43	58.08	53.35	62.52	69.10	70.01	74.61	68.86	73.86	68.64	72.79
D	53	53	66.53	63.23	62.52	66.72	64.48	60.80	67.44	68.18	69.57		
D	53	61	66.96	70.60	72.18	76.92	73.46	69.40	67.21	68.63	58.72	50.75	54.09
D	53	62	57.43	58.08	53.35	62.52	69.10	70.01	74.61	68.86	73.86	68.64	72.79
D	53	63	66.53	63.23	62.52	66.72	64.48	60.80	67.44	68.18	69.57		
D	53	71	66.96	70.60	72.18	76.92	73.46	69.40	67.21	68.63	58.72	50.75	54.09
D	53	72	57.43	58.08	53.35	62.52	69.10	70.01	74.61	68.86	73.86	68.64	72.79
D	53	73	66.53	63.23	62.52	66.72	64.48	60.80	67.44	68.18	69.57		

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4 WINDS

W	53	51	3.000	4.300	5.400	3.200	3.400	5.300	3.000	3.800	4.000	6.500	6.100
W	53	52	3.800	3.700	3.300	4.000	4.400	3.000	2.700	2.000	2.800	4.800	5.500
W	53	53	4.300	3.900	4.300	2.900	3.500	3.400	3.200	3.300	2.900		
W	53	61	3.000	4.300	5.400	3.200	3.400	5.300	3.000	3.800	4.000	6.500	6.100
W	53	62	3.800	3.700	3.300	4.000	4.400	3.000	2.700	2.000	2.800	4.800	5.500
W	53	63	4.300	3.900	4.300	2.900	3.500	3.400	3.200	3.300	2.900		
W	53	71	3.000	4.300	5.400	3.200	3.400	5.300	3.000	3.800	4.000	6.500	6.100
W	53	72	3.800	3.700	3.300	4.000	4.400	3.000	2.700	2.000	2.800	4.800	5.500
W	53	73	4.300	3.900	4.300	2.900	3.500	3.400	3.200	3.300	2.900		

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T	999953	53	86	66	88	61	89	62	89	68	90	66	91	65	95	68	94	72	94	71				
T	999953	61	96	68	94	71	91	71	85	67	91	73	95	75	85	71	85	69	85	64	80	56	81	57
T	999953	62	82	58	83	62	85	57	86	62	86	68	85	70	78	67	88	68	90	68	88	72	77	71
T	999953	63	86	66	88	61	89	62	89	68	90	66	91	65	95	68	94	72	94	71				
T	999953	71	96	68	94	71	91	71	85	67	91	73	95	75	85	71	85	69	85	64	80	56	81	57
T	999953	72	82	58	83	62	85	57	86	62	86	68	85	70	78	67	88	68	90	68	88	72	77	71
T	999953	73	86	66	88	61	89	62	89	68	90	66	91	65	95	68	94	72	94	71				

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3 RAD DAILY

R	53	51	665.0	413.0	293.0	243.3	510.6	539.9	222.6	343.3	578.5	656.9	688.4
R	53	52	561.9	531.8	626.6	467.8	390.1	272.5	141.6	514.0	596.6	497.6	97.7
R	53	53	506.3	625.8	676.0	613.8	616.8	637.6	622.6	542.2	437.8		
R	53	61	665.0	413.0	293.0	243.3	510.6	539.9	222.6	343.3	578.5	656.9	688.4
R	53	62	561.9	531.8	626.6	467.8	390.1	272.5	141.6	514.0	596.6	497.6	97.7
R	53	63	506.3	625.8	676.0	613.8	616.8	637.6	622.6	542.2	437.8		
R	53	71	665.0	413.0	293.0	243.3	510.6	539.9	222.6	343.3	578.5	656.9	688.4
R	53	72	561.9	531.8	626.6	467.8	390.1	272.5	141.6	514.0	596.6	497.6	97.7
R	53	73	506.3	625.8	676.0	613.8	616.8	637.6	622.6	542.2	437.8		

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7 READIN

1 DATA AND SIMULATION OF WALKER BRANCH WATERSHED

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.157	.2017	.2333	.2417	.2417		
0.25						
1.0132	.24	10.	100.	0.0		
.2	.01	.6	.4	20.	400.	5000.0
.001	6.0	0.0	20.0			
300000.	.001	.001				
80.	130.	260.	306.			
2.0	1.0	2.	1.	.12	.10	
0.6	0.48	5	3			
34.	20.	250.	250.	-0.5	-0.5	
0.0	180.	36.0				

PULLERTON A2/S WALKER BRANCH

9	50	.27	21.8	0.0		
73.49	0.999	.01138	15.	980.		
2.0						
.125.143.159.170.187.210.240.263.270						
15000. 5000. 1000. 667. 333. 100.	25.	5.	0.			

PULLERTON B21/S WALKER BRANCH

9	50	.246	10.9	0.0		
73.49	0.999	.01138	15.	980.		
2.0						
.166.177.187.193.201.211.225.236.246						
15000. 5000. 1000. 667. 333. 100.	25.	5.	0.			

PULLERTON B221/S WALKER BRANCH

9	50	.304	10.9	0.0		
73.49	0.999	.01138	15.	980.		
2.0						
.184.198.211.218.226.257.278.298.304						
15000. 5000. 1000. 667. 333. 100.	25.	5.	0.			

INFILTRATION CURVE/S FOREST SOIL

15.	0.0	0.0	21																
.00	.25	.50	.75	1.	2.	4.	6.	8.	10.	12.	14.	16.	18.	20.	22.				
24.	26.	28.	30.	60.															
.00	.15	.83	1.75	2.74	6.82	15.00	23.29	31.57	39.86	48.15	56.44	64.72	73.01	81.30	89.59				
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