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Teja Singh (1972)

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ASPEN-GRASSLAND WATERSHED.

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ESTIMATING INFILTRATION RESPONSE OF VEGETATION UNITS IN AN
ASPEN-GRASSLAND WATERSHED

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(H 10) T. Singh. Estimating Infiltration
Response of Vegetation Units in an Aspen-
Grassland Watershed.

S Y N O P S I S

A general linear statistical model was used to estimate infiltration rates of vegetation units represented in an aspen-grassland watershed in southwestern Alberta. The model provided a highly satisfactory fit to the numerical data and 20 out of a total of 24 analyses attempted for initial, steady and total infiltration showed R^2 values of 90 percent and over. None of the edaphic factors of physical significance, however, proved to be equally important in all the analyses and indicated overlap of information content. No single variable, or a simple combination of a few selected variables, provided a valid estimate of infiltration even though some of these variables were highly significant individually.

A simple infiltration-time weighted regression model improved the predictions considerably and resulted in R^2 values ranging from 93.3 to 98.5 percent. Another empirical model similarly explained nearly all of the variation for accumulative infiltration.

The two models showed equally high R^2 values when tested on different sets of infiltration data.

THEORETICAL DERIVATION

The general linear model used with concomitant variables was of the form

$$Y = \beta_0 + \sum_{i=1}^n \beta_i X_i + e \quad (1)$$

where Y is the observed random variable, β 's are unknown parameters, X the vegetative and edaphic variables, and

e the unobservable random element such that $E(e) = 0$ and $\text{Var}(e) = \sigma^2$. The model was used in a step-wise regression for initial, steady and total infiltration rates.

INFILTRATION-TIME FUNCTIONS

(a) Infiltration rate

The function selected was

$$Y_i = \int_{X_{i-1}}^{X_i} (a + be^{-cX}) dX \quad (2)$$

where X is the time interval at which the infiltration rate Y is to be estimated. For equal time increments equation (2) reduces to

$$Y_i = a + d (e^{-cX_{i-1}} - e^{-cX_i}) \quad (3)$$

where $d = b/c$.

As the area of steepest change is in the region of initial time intervals, extra readings need to be taken in the beginning and the equation (2) in case of unequally spaced time increments can be written as

$$Y_i = a (X_i - X_{i-1}) + d (e^{-cX_{i-1}} - e^{-cX_i}) \quad (4)$$

The e in equations 2, 3 and 4 is the base of natural logarithms, and a , b and c are constants for a given vegetation unit.

A weighted regression technique in which the weight W_i was taken as the reciprocal of sample variance of Y 's at time X_i , was further used to improve the fit.

(b) Mass infiltration

A function of the form

$$Y_i = a + bX_i - ce^{-kX_i} \quad (5)$$

was used for estimating accumulative infiltration up to time X_i . As the variance of Y 's was found to increase with time, the weighted regression technique stated above yielded considerable improvement in fit.

The method of least squares was used to obtain the best fit for all models.

CONCLUSIONS

The general linear model, based on measurements of 18 vegetative and edaphic variables of physical importance, provided a very good fit to the field infiltrometer data; 20 out of 24 analyses resulted in R^2 values ranging from 90 to 100 percent. However, no single variable or a linear combination of a few selected variables provided a good estimate of infiltration even though such variables were highly significant individually.

The infiltration-time functions, with the numerical constants determined separately for each vegetation unit, fitted the data excellently:

<u>Vegetation Unit</u>	<u>Infiltration Rate Model</u>	<u>Mass Infiltra- tion Model</u>
	<u>$R^2 \times 100$</u>	<u>$R^2 \times 100$</u>
<u>Grassland</u>		
Upland grass type (fescue, oat grass)	97.7	100
Valley bottoms (timothy)	94.9	100
Slopes (grasses and forbs)	98.5	100
<u>Shrubs</u>		
Willow and birch	96.0	100
<u>Forest</u>		
Black poplar	98.5	100
Aspen (rose understory)	96.9	100
Aspen (pine grass understory)	97.5	100
Aspen (fireweed, showy aster understory)	93.3	100

The two models similarly provided excellent results when applied to different sets of infiltration data obtained from neighbouring areas in which aspen forest had been cleared in the past and converted to grassland:

	<u>Untreated</u>	<u>Treated</u>	<u>Untreated</u>	<u>Treated</u>
Area I	98.4	98.7	100	100
Area II	98.1	93.8	100	100
Area III	98.1	97.0	100	99.9

Statistical analyses indicate the feasibility of deriving single equations for the entire watershed and the possibility of extending the experimental results to the montane aspen forests and associated grasslands of the southern foothills in general.

KEY REFERENCES

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