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Wind flow profiles over pine plantations

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1 Introduction

1.1 Context

This paper responds to a request from the secretary of Research Working Group 6 (RWG6) of the Australian Forestry Council to prepare a paper on 'wind flow profiles over pine plantations' for the July 1990 meeting of RWG6.

1.2 Literature

Baughman (1981) produced a bibliography of items that deal with wind speed and its relation to forest fire behaviour studies. This was updated by conducting a literature search of Meteorological and Geophysical Abstracts using the key words 'wind profile' and 'pine'. This yielded only ten entries. (Appendix 1). The reason for this is:

i) most of the work on wind profiles in forests has been done in forests other than pine;

ii) present scientific interest is in the turbulence characteristics of the wind, rather than in a study of the wind profile.

The criteria for the literature search were increased by using the key words 'wind' and 'pine'. This increased the number of entries to 42, which are also given in Appendix 1.

2 Winds over forests

The near-surface mean wind, u, under neutral conditions can be described by the logarithmic wind profile during neutral stability:

$$u = \frac{u_*}{k}\ln\left(\frac{z-D}{z_o}\right) \qquad \ldots(1)$$

where z is the height above ground, z_0 is the roughness length, D is called the zero plane displacement, u_* is the friction velocity - also known as the shear velocity - and k is von Karman's constant which has a value of 0.4

The roughness length, z_0, over land is related to the height and spacing of obstacles on the ground. Measurements show that z_0 varies from about 0.1mm over ice or water to several metres over cities or tall forests. It is a measure of the efficiency of momentum transfer into the ground. Tables, each with slightly different representative values of z_0, may be found in most modern meteorological textbooks.

Attempts have been made to relate z_0 to obstacle heights. If the mean height of the roughness obstacle is h, then the form $z_0 = c\,h^a$ has often been assumed. Paeschke (1937) obtained $c = 4/30$ and took $a = 1$. Kustas and Brutsaert (1987) point out that, similar values for c, close to 0.1, have been found by many others, especially for dense surfaces with vegetation. Jarvis et al. (1976), in a review of coniferous forests, reported values of z_0/h for 15 stands that varied between 0.02 and 0.14; the mean and standard deviation being 0.076 ± 0.047. This is smaller than the oft-quoted 0.1 which seems to be more appropriate to farm crops. Shuttleworth (1989) notes that the two can be reconciled if $z_0 = (h - D)/3$.

As z_0 represents eddy size at the surface, it must depend not only on obstacle height, but also on the shape and spacing of surface features. Lettau (1969) proposed that $z_0/h = c_s\lambda$ where c_s is a constant, and λ is the roughness density defined as the ratio of i) the silhouette area of the average obstacle (i.e. the area transverse to the wind direction) to ii) the area taken up by an average individual obstacle. (i.e. divide the total ground area occupied by the obstacles by their number). Lettau (1969) proposed $c_s = 0.5$, but subsequent work found that c_s still varies with roughness element shape. Wooding et al. (1973) obtain

$$\frac{z_o}{h} = \lambda\left(\frac{h}{s}\right)^{0.4} \quad \ldots(2)$$

where s represents the streamwise (i.e. horizontal, parallel to the flow) dimension of the roughness elements. This formula is akin to that cited by Justus (1985: p.924) namely

$$z_0 = 0.056h^{1.37} \quad \ldots(3)$$

Garratt (1977) graphed the results of these studies, as shown in Figure 1. This indicates that z_0 /h can only be described by a power law in λ over a restricted range. At high values of λ (i.e. elements closely packed), z_0 /h is small.

2.1 Zero-plane displacement (D)

The ratio D/h is less sensitive than z_0 to the nature of the surface. For natural crop-covered surfaces D/h ranges from about 0.64 to 0.68. A number of authors treat $D = (2/3)h$ as representative. Jarvis et al. (1976) found that for the coniferous forest that they reviewed, D/h ranged form 0.67 to 0.92 with a mean and standard deviation of 0.78 ± 0.09. This value is significantly larger than the 2/3 normally quoted. Shuttleworth (1989) suggests that it probably reflects the longevity of forest stands, and the ensuing tendency to have more foliage near the top of the canopy.

The best way of determining z_0 and D for a particular forest or stand is to collect vertical wind data under neutral conditions well above the canopy and optimise Eq. 1. More recently, Lo (1990) has suggested that it is possible to estimate z_0 from wind profiles in and above a forest canopy. Alternative procedures that speculatively assign physical significance to D (Molion & Moore, 1983) are controversial (Lo, 1990), as discussed in section 4.2.

2.2 Atmospheric stability and instability

There are many different ways of characterising the stability of the atmosphere. Near the earth's surface, the atmosphere will be unstable whenever there is an upward flux of sensible heat, F. The ground is then potentially warmer than the overlying air and parcels of buoyant air are carried upwards. If the wind is strong, then conditions tend towards neutral stability in which air parcels have neither upward nor restoring forces on them. At night, with surface cooling, the atmosphere is stable and a displaced parcel of air tends to move back to its original position.

Atmospheric stability affects the mean wind profile. The Monin-Obukhov similarity theory implies that the formula for the vertical wind shear du/dz obtained from Eq. 1 is modified so that

$$\frac{\mathrm{d}u}{\mathrm{d}z} = \frac{u_*}{k(z-D)}\Phi\left(\frac{z-D}{L}\right) \quad \ldots(4)$$

where Φ, which is a measure of stability, is a function of L, the Monin-Obukhov length. For a neutral atmosphere, L is infinite and Φ is unity. For unstable air (for which L is negative) , the Businger-Dyer form is used for Φ

$$\Phi = \left(1 - 16\frac{[z-D]}{L}\right)^{-0.25} \quad \ldots(5)$$

whereas for stable air (for which L is positive) the Webb (1970) form is used

$$\Phi = 1 + 5\frac{(z-D)}{L} \quad \ldots(6)$$

If we neglect atmospheric moisture effects then the Monin-Obukhov length is

$$L = -\frac{u_*^3 c_p \rho T}{k g F} \qquad \ldots(7a)$$

where c_p, ρ, k and g are the isobaric specific heat of air, the air density, von Karman's constant and the acceleration due to gravity respectively. Substituting the known values for these parameters (in SI units) the Monin-Obukhov length (in metres) evaluates to

$$L = -\left(\frac{10^6}{11}\right)\frac{u_*^3}{F} \qquad \ldots(7b)$$

where F is the sensible heat flux (in W m^{-2}) and u_* is called the friction velocity (or shear velocity, in units of m s^{-1}).

2.3 Stability class and stability category

The air-pollution community characterises atmospheric stability in terms of broad classes designated A to G (the Pasquill stability category), or 1 to 7 (the P class). Figure 2 reproduces an informative diagram from Beer (1990) showing how these relate to upward heat flux and wind speed. Basically, category A (class 0 to 1) is the most unstable, category D (class 3 to 4) is neutral stability, and class G (category 6 to 7) is the most stable.

2.4 Validity

Garratt (1980) found that the logarithmic profile is not established until about 4.5h - the exact value depends on λ, the roughness density and can range from 3h to 8h (above the zero-plane displacement). Conversely, the logarithmic profile is valid up to a height about 1/10 of the planetary boundary layer depth. Thus it is valid up to about 100m during daytime. The similarity form of the near-surface wind profile is suspect when

1) the anemometer height is less than 5 times the vegetation height (Garratt, 1980)

2) $|(z-D)/L| > 2$ in the unstable case

3) $(z-D)/L > 1$ in the stable case.

Condition 2 is probably the least serious as is there is evidence that the Businger-Dyer form can be useful for larger values of $|(z-D)/L|$. (van Ulden & Holtslag, 1985)

3 Winds inside forests

There is considerable variation in the wind speed inside the forest. This arises from a number of causes including the character, orientation and spacing of the trees and their canopies, and the turbulence generated by the canopy itself. This last point can be especially noticeable in light wind conditions. Lo (1990) quotes a finding that when smoke puffs are used to investigate air flow in a forest there is little correlation between wind directions above and below the crown at low wind speeds. The direction of flow within the canopy is sometimes opposite to that of the wind above it.

Figure 3 is taken from the classical work of Geiger (1965). It shows the wind profile in a thin fir stand in Bavaria under three different wind speeds and illustrates that air movement is less restricted in a trunk area free of branches - particularly when the wind can blow in through the open borders of the stand. The presence of a uniform vertical wind speed, as shown for low wind speeds, can only be accomplished by turbulent mixing. Fig. 3 also shows the development of a thin shear layer near the ground where the wind speed drops to zero. Oliver (1971) measured wind speed profiles in a mixture of Scots and Corsican Pine, and obtained a mean wind profile similar to that of Geiger's 2 m/s profile.

Since Geiger's time it has become standard to present the plot of mean wind at a height z within and under the canopy in terms of non-dimensionalised variables, z/h and u_z and u_h where h is the mean canopy height, u_z and u_h are the mean wind speed at heights z and h respectively. Fig. 4 reproduces the plots of Fritschen (1985) who use them to show how various vegetative canopies alter the mean wind profile.

3.1 Theory

There are various theoretical attempts to explain the vertical profile of the mean wind. The wind stress is given in terms of the friction velocity, u_*, or the drag coefficient C_d by

$$\tau = \rho u_*^2 = \rho C_d^2 u^2 \qquad \ldots(8)$$

which has a constant value for any particular value of u. The term ρ represents the density of the air. Near, and within, the canopy Eq. 8 will no longer be adequate. In the simplest approach, the stress divergence in the air, $\partial\tau/\partial z$, is assumed to balance the foliage drag per unit volume of air, D_f, so that:

$$\frac{d\tau}{dz} = D_f \qquad \ldots(9).$$

In practically all derivations it is further assumed, firstly that the shear stress is proportional to the velocity gradient. This assumption is generally called the K-theory approach because the proportionality constant, which is known as the eddy viscosity, is represented by the symbol K:

$$K = \frac{(\tau/\rho)}{(du/dz)} \qquad \ldots(10)$$

and secondly that D_f is proportional to u^2 in an analogous manner to C_d

$$D_f = A_f C_{df} \rho u^2/2 \qquad \ldots(11)$$

where A_f is the surface area (both sides) of leaves per unit volume of air, and C_{df} is a foliage drag coefficient. A_f is related to the leaf area index

$$\mathrm{LAI} = \frac{1}{2}\int_0^h A_f dz \qquad \ldots(12).$$

The leaf area index is the area (one side) of foliage per unit area of ground surface and is a parameter used in radiation studies.

For a given A_f and z in a given type of vegetation C_{df} is probably a function of Reynolds number. The matter is complicated in actual canopies, however, due to the distribution of angles of attack of the leaves, the variety in their shapes and their mutual interference which depend on the foliage density $A_f(z)$. Thom (1971) concluded that C_{df} is proportional to $u^{-1/2}$ for an artificial crop consisting of cylinders and for beans, though Seginer et al. (1976) found C_{df} to be a constant for a model canopy of slender rods.

3.2 Profiles

If it is assumed that the product $A_f C_{df}$ is a constant, that

$$K = l^2 \left| \frac{du}{dz} \right| \quad ...(13)$$

and that the mixing length, l, is also a constant, then one obtains the exponential profile, introduced independently by Inoue (1963) and Cionco (1965)

$$u = u(h_o)\exp\left[-a\left(1-\frac{z}{h_o}\right)\right] \quad ...(14)$$

where $u(h_o)$ is the mean velocity at $z = h_o$ and a is an extinction parameter. Brutsaert (1982: p. 101) gives a different derivation which does not invoke a mixing length hypothesis.

Different assumptions about the nature of K lead to slightly different profiles. Cowan (1968) obtained a hyperbolic sine profile. If both K and $A_t C_{dr}$ are taken as constants (Landsberg & James, 1971; Thom, 1971) then one obtains

$$u = u(h_o)\left\{1 + a'\left(1-\frac{z}{h_o}\right)\right\}^{-2} \quad ...(15)$$

where a' is another parameter.

It is not easy to identify which, if any, of these assumptions are valid. Nevertheless, all three give a mean velocity which is decaying with depth and the differences among them, when fitted to data, are usually well within the scatter observed in field experiments. In fact, Albini & Baughman (1979) assume a constant wind speed below the canopy and claim good agreement between their theory and observations.

Jarvis et al. (1976: p. 196-198) in discussing these results point out that Eq. 15 implies that the bulk fluxes of air from the upper parts of the canopy must be large. Shuttleworth (1989) expresses the same idea in a different way when he states that the vertical mean wind speed profile is inconsistent with a monotonic loss of momentum through the canopy, and is indirect evidence of countergradient flow.

3.3 Bursts and sweeps

The occurrence of a rapid air flow, or 'blow-through', below the crowns is evident in the results of Geiger (1965). It was originally ascribed to penetration from the edge of the stand, or from large breaks in the canopy. But the finding that blow-through occurs also in near-ideal conditions of fetch, as at Thetford (Oliver, 1971) led Jarvis et al. (1976) to conclude that it is a general phenomenon arising from horizontal pressure gradients which are sustained by persistent up-and-down draughts at varying points in the stand.

Both wind tunnel observations (Cantwell, 1981) and field observations (Raupach, 1988) indicate that immediately above a surface - such as the wall of a wind tunnel, or the canopy of a forest - longitudinal 'streaks' of low velocity flow are formed (as a consequence of instability arising from the strong shear between the wind above the surface, and that at the surface). These streaks are the potential source of turbulence, which is suddenly released and ejected into the outer layers of the flow in a process that is initiated by inrushes of high momentum fluid from above (called 'sweeps'). These downward-moving, intense, gusts are the dominant turbulent events. They have a horizontal length scale of the order of h, the canopy height and are intermittent in occurrence. The return flow is composed of lower momentum 'bursts' that remove the momentum from the canopy.

The implication in these findings, namely that K-theory in forest canopies is inappropriate, means that the meteorological community needs to actively work on methods with which to model (and hence predict) the details of the wind-field in a forest. The simple forms described in section 3.2 can be used to give approximate answers, but only direct measurement will enable the fire-fighter to know the details of what he is likely to expect in terms of a forest wind-field. One thing does seem clear - no matter how dense the canopy, the region below it will be subject to intermittent strong sweeps of air.

4 Winds at forest edges

Even though there may be a secondary wind maximum underheath the canopy, the magnitude of this wind will be much less than that above the canopy. Yet outside a forest, say over a large grass fetch, we know that the wind at a corresponding height will be stronger than that inside a forest.

There are at least two issues of relevance. Firstly, if anemometer measurements are taken in the open, how can they be used to infer the wind speed inside the forest. Secondly, how far do edge effects penetrate into the forest.

4.1 Inferring forest winds from outside measurements

The problem of inferring within-canopy forest winds from outside measurements will frequently arise in forest-fire management and control because guidelines for the establishment of meteorological stations are such that forested areas fail to meet them. It should first be pointed out that there is no theoretically satisfactory simple way in which to handle this problem - even in the ideal case of an abrupt transition from a uniform grassland with a long fetch to a homogeneous forest of trees of uniform height.

The most promising advance is that of Li et al. (1990) who solve the averaged momentum equations and parameterise K in a way which they claim describes the sweep-burst mechanism described above. They check their model against the pine-forest observations of Raynor (1971) and the agreement is impressive (Figure 5). In part, this may arise from the fact that Raynor (1971) failed to measure at least one critical parameter required by the model, namely the vertical distribution of the leaf surface area density, and Li et al. (1971) were thus free to specify it.

4.2 Edge effects

What fetch is needed for a new steady-state wind profile to be established following a change in surface roughness? There are numerous wind tunnel and atmospheric studies on the problem which are reviewed by Garratt (1990). Basically, an internal boundary layer (IBL) forms which grows downstream. Above the IBL the flow field is that of the upstream conditions except for a displacement δ (upward in the case of grass to forest). A number of authors have equated δ with the zero-plane displacement, but Lo (1990) shows that this is incorrect. There appears to be no simple rule allowing one to estimate δ.

There is an inner equilibrium layer inside the IBL which has a height that is about one-tenth of the IBL height. Far downstream of the leading edge, in neutral conditions, the inner equilibrium layer is characterized by a logarithmic profile appropriate to the new roughness. If we denote the height of the inner equilibrium layer by H, then Garratt (1990: Eq. 22) predicts that at a downstream distance x it is given by

$$\zeta \ln \zeta - \zeta + 1 = x/(2z_o) \qquad \ldots(16)$$

where z_o is the roughness length of the downstream roughness element and

$$\zeta = 10H/z_o \qquad \ldots(17).$$

This assumes that H is one-tenth of the IBL height. If we further assume that z_0 is one-tenth of h, the canopy height, then it is possible to determine the minimum fetch, X, required for a satisfactory wind speed reading in the new downstream roughness. To obtain X use the result that a logarithmic profile is only established at $H = 5h$. Substitution then reveals that the requisite fetch is $X = 520h$.

In relation to airflow to and from forests, the situation is similar to that described in section 4.1 in that Li et al (1990) seem to provide the only realistic model, and one needs to examine data - such as that of Raynor (1971) - to provide rules of thumb. These results, as shown in Fig. 5, indicate that edge effects penetrate a maximum distance of four times the canopy height. It is unclear how this distance depends on the spacing between trees (sometimes referred to as the porosity), except for the common-sense notions that the distance should be zero if the trees form a solid barrier, and should be infinite if the trees are vanishingly sparse.

4.3 Windbreaks

Results on windbreak studies in the field and laboratory are reviewed by Plate (1971: p.161) and more recently by Taylor (1988). It is disappointing to see how little new work has been done in the intervening 17 years, and the situation is even more depressing when one realises that much of the work summarised by Plate (1971) is from Geiger (1965). One could wrongly imagine that everything one needs to know on such an important topic is already known. What is known is that:

* Potentially beneficial reductions in wind speed can occur for short distances ($2h$ to $4h$) upstream of the windbreak and over much longer distances in the lee ($20h$ to $40h$); where h is the canopy height
* Windspeed reductions immediately downwind of the windbreak are greatest with a solid or closed windbreak, but the greatest overall shelter is obtained with windbreaks of about 50% porosity, as shown in Fig. 6.

4.4 Firebreaks

Raupach (1988) points out that turbulent events (i.e. bursts and sweeps) within the canopy are coherent on length scales of the order of h, the canopy height. This observation, combined with the results of Raynor (1971), implies that firebreaks whose width exceed the canopy height will experience increased wind speeds - and at two canopy heights the canopy wind will be transferred down to the firebreak.

5 Practical implications

Fritschen (1985) notes some of the problems involved in the measurement of wind in the forest. He cites some of the 'rules of thumb', mainly based on wind-tunnel studies, which apply to measurement of wind above a horizontal surface. These include:

* The lowest anemometer should be situated at least 5 times above the average roughness of the surface or the structure of the canopy surface
* The maximum height of the anemometers should not exceed 1/50 of the upwind fetch.
* The minimum distance of 8 times the downwind obstacle height should be added to the fetch obtained from instrument height considerations
* The minimum distance upwind from a roughness change should be at least 6 times the change in roughness.

Fritschen (1985) then proceeded to show that most forest experimental sites violate these rules. In fact, the manner in which Fritschen (1985) applied these rules does not appear correct, and it is worth examining each one in detail to see how it was derived, what it means, and what are its limitations. Fig. 7 illustrates the application of these rules.

5.1 The lowest anemometer should be situated at least 5 times above the average roughness of the surface or the structure of the canopy surface

Garratt (1978, 1980) showed that below this height it is unlikely that a logarithmic profile will be established, even under neutral conditions.

5.2 The maximum height of the anemometers should not exceed 1/50 of the upwind fetch.

This is an attempt to set a fetch criterion based on some early wind tunnel work. The way it is expressed is probably correct, but the opposite is not necessarily true in that anemometer heights below 1/50 of the fetch may still be too large. Consider Fig. 7 which is annotated on the basis of the results of Eqs. 16 and 17. A fetch of more than 500 h is needed to obtain valid anemometer readings at a height of $5h$. Though it is therefore true that the anemometer height should not exceed 1/50 of the upwind fetch, heights exceeding 1/100 of the upwind fetch will be outside the inner equilibrium layer.

5.3 The minimum distance of 8 times the downwind obstacle height should be added to the fetch obtained from instrument height considerations

This recommendation is intended to allow for edge effects and effectively says that in a porous boundary, wind effects penetrate up to $8h$, and the fetch should be measured only beyond this distance. The numerical value will depend on the porosity of the forest. The results of Raynor (1971) shown in Fig. 5 indicate that $4h$ would have been adequate for his forest.

5.4 The minimum distance upwind from a roughness change should be at least 6 times the change in roughness.

This recommendation allows for the fact that airflow streamlines are affected before they meet a change in roughness. The distance of upstream disturbance is less than the distance of penetration into the forest, but both will depend on the porosity of the forest. The results of Fig. 5 indicate that a value of about $2h$ would have been sufficient in that particular case.

5.5 Applicability of the rules

It should by now be clear that the above rules have been developed so that the instrument will provide a reliable estimate of the near-surface wind field which is synoptically relevant. They are designed to produce a wind field estimate that can be extrapolated upwards, not one that can be extrapolated downwards. They are not designed to provide information on the wind-field close to, or within, the canopy.

6 Discussion

The above exposition is limited to the case of a uniform canopy on level ground under conditions of neutral atmospheric stability. The forest, or pine-plantation has been assumed to be two-dimensional - extending off to infinity in the direction transverse to the wind. None of these assumptions will hold in real pine-plantations and the violation of each assumption will introduce new complexities into the wind speed profiles.

The most difficult future problem appears to be that of canopies in hilly terrain. The reason for this is that the nature of the airflow over barren hills is still an area of active research. Until more is known about this conceptually simpler problem, we are unlikely to be able to deal scientifically with the more complex situation of canopies on hilly terrain, though the operational forester will rely on climatology supplemented by common-sense to guide his operations. Thus guidelines to minimize windfall following cuttings in mature and overmature stands (Alexander, 1964) caution against locating cutting boundaries where they will be exposed to accelerated winds funneling through saddles in ridges to the south and west of the area, especially if the ridges are at higher elevation. Though these directions refer to United States conditions they sound useful in the southern parts of Australia where southwesterlies predominate.

7 Conclusions

To conduct research on wind fields in pine plantations requires:

Instrumented towers that extend to at least 10m above the top of the canopy.

Wind measuring instruments that can sample all three components of the wind.

Instruments capable of measuring and recording the turbulent fluctuations.

Sufficient spatial coverage to be able to deduce the two-dimensional nature of the wind field.

It is not surprising that there are few organisations equipped to conduct serious research on winds in canopies, and that one finds the same data sets [e.g. that of Raynor (1971)] being used by theoreticians to validate their models. The model of Li et al. (1990) holds great promise in this regard and offers plantation managers the possibility of being able to predict mean winds within their plantations. Implementing it within Australia, calibrating it and validating it against some local data would be an enormously useful research project.

Nevertheless, the recent understanding of the potential importance of bursts and sweeps highlights how little is known of the statistics of their occurrence, their spatial distribution, and their interaction with clearings in the forest. Sweeps show up as sharp jumps in temperature (Bergström & Högström, 1989) so that it may be possible to answer particular questions about them using relatively simple equipment. Such questions include:

Are there preferential locations for the occurrence of sweeps? If so, do clearings act as such preferential locations?

Can one develop a statistical climatology for the amount of time bursts and sweeps take place?

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9 Figures

1 Variation of z_0 / h as a function of λ - the roughness density. (Garratt, 1977)

2 Relationship between stability category, sensible heat flux and 10 cm wind speed for a 10 cm roughness length. The solar radiation scales at the top are roughly in accord with warm ocean and with arid zone conditions (Beer, 1990: p. 36).

3 Wind profiles in a stand of pine for three ranges of wind speed (Geiger, 1965: p. 312)

4 Comparison of normalised wind profiles of various vegetative canopies where Z is the height above ground, H is the height of the canopy and U is the wind speed. (Fritschen, 1983). The profiles are 1 - dense cotton, 2 - Douglas fir forest, 3 - dense conifer with understorey, 4 - moderately dense conifer with no understorey, 5 - dense hardwood jungle with understorey, 6 - isolated conifer stand.

5 Comparison of the results of the model of Li et al. (1990) with the results of Raynor (1971) on the wind speed within and outside a pine forest.

6 The effects of a windbreak, given as a percentage of wind speed reduction, for different porosities (Plate, 1971: p. 167)

7 Schematic diagram (not to scale) showing the internal boundary and equilibrium layers and their relationship to various 'rules-of-thumb' for the siting of anemometers.

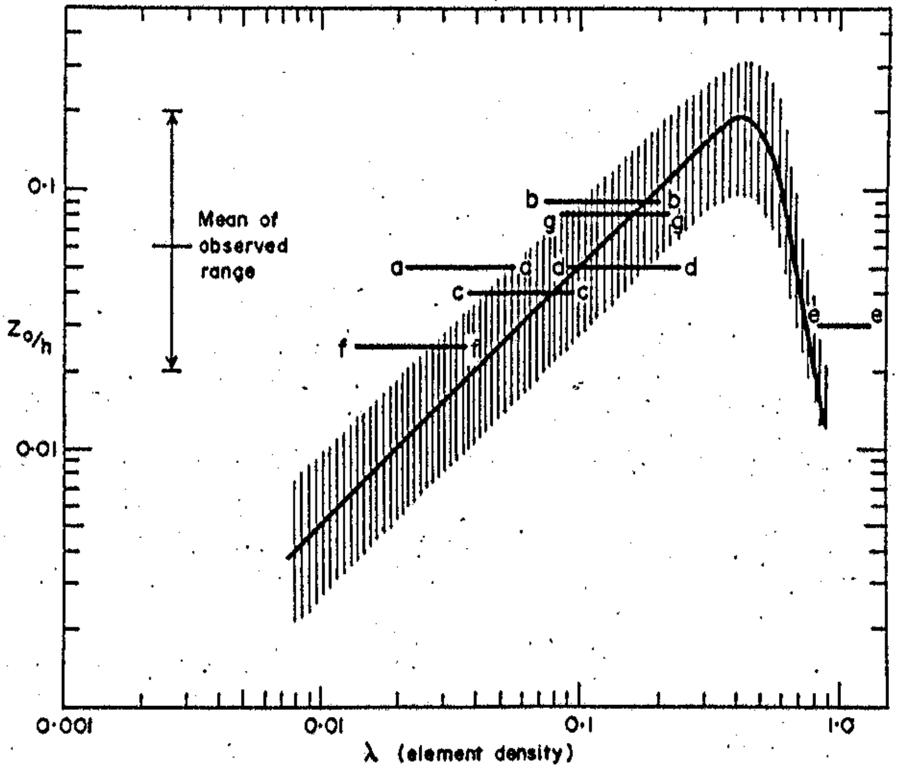
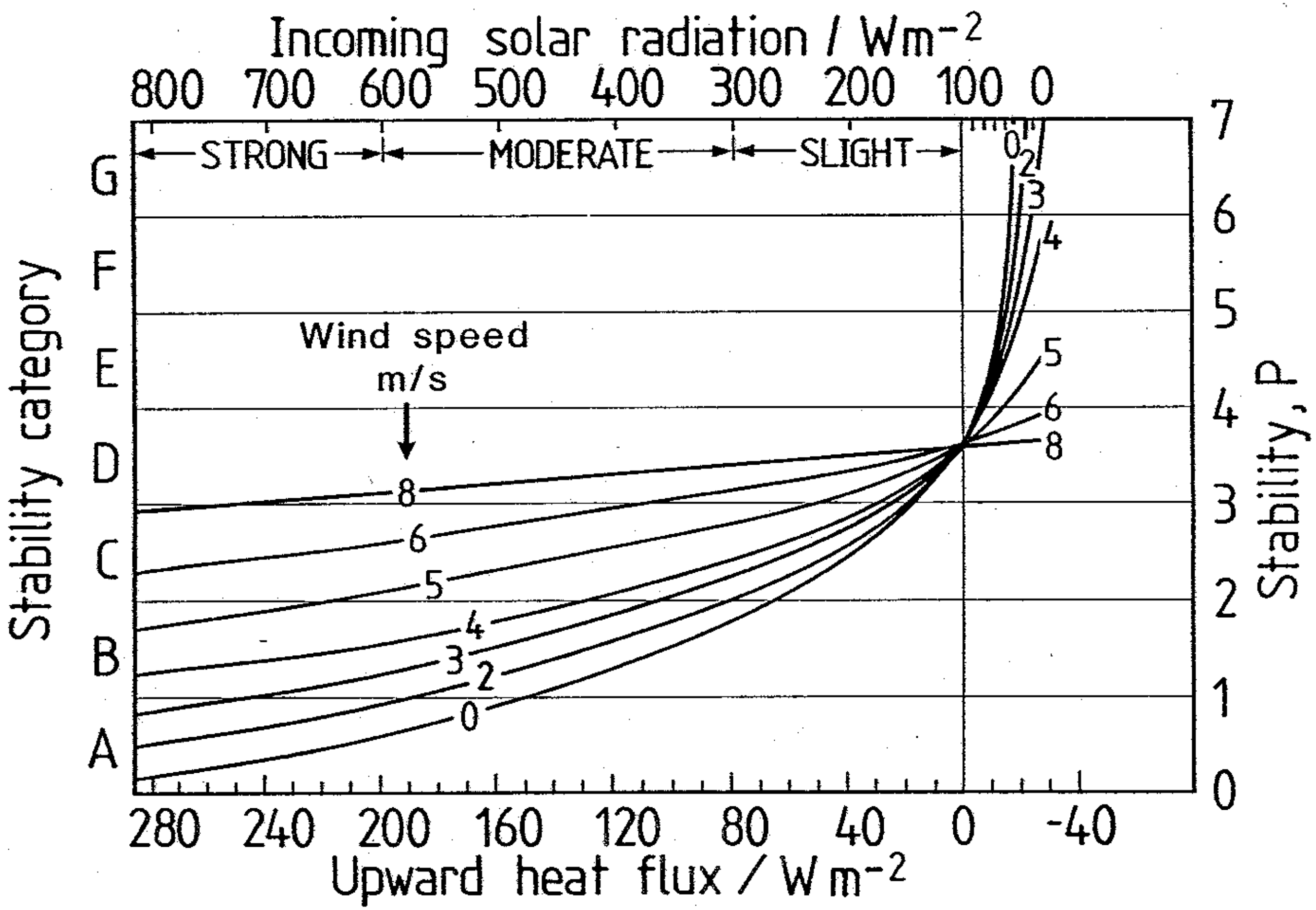


Fig. 1. Variation of z_0/h with roughness element density λ based on results of Kutzbach (1961), Lettau (1969) and Wooding *et al.* (1973). The shaded area indicates uncertainty in z_0/h for a given λ when the mean curve is applied to natural surfaces. The observed atmospheric range in z_0/h (see Table 2) is shown, and data from Table 1 are also plotted as horizontal bars separating λ_1 and λ_2 values. The lettering code is as follows (see Table 1): a, trees (M1); b, trees (M2); c, wheat (early in season); d, wheat (late in season); e, pine forest; f, vineyard (flow parallel to rows); g, vineyard (flow normal to rows).

Fig 1



Incoming solar radiation / Wm-2
800 700 600 500 400 300 200 100 0
STRONG
MODERATE
SLIGHT
Wind speed
m/s
Stability category
G
F
E
D
C
B
A
Stability, P
7
6
5
4
3
2
1
0
8
6
5
4
3
2
0
280 240 200 160 120 80 40 0 -40
Upward heat flux / W m-2

Fig 2

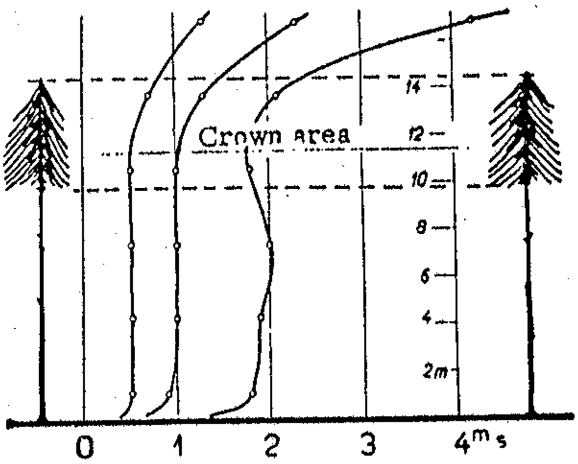
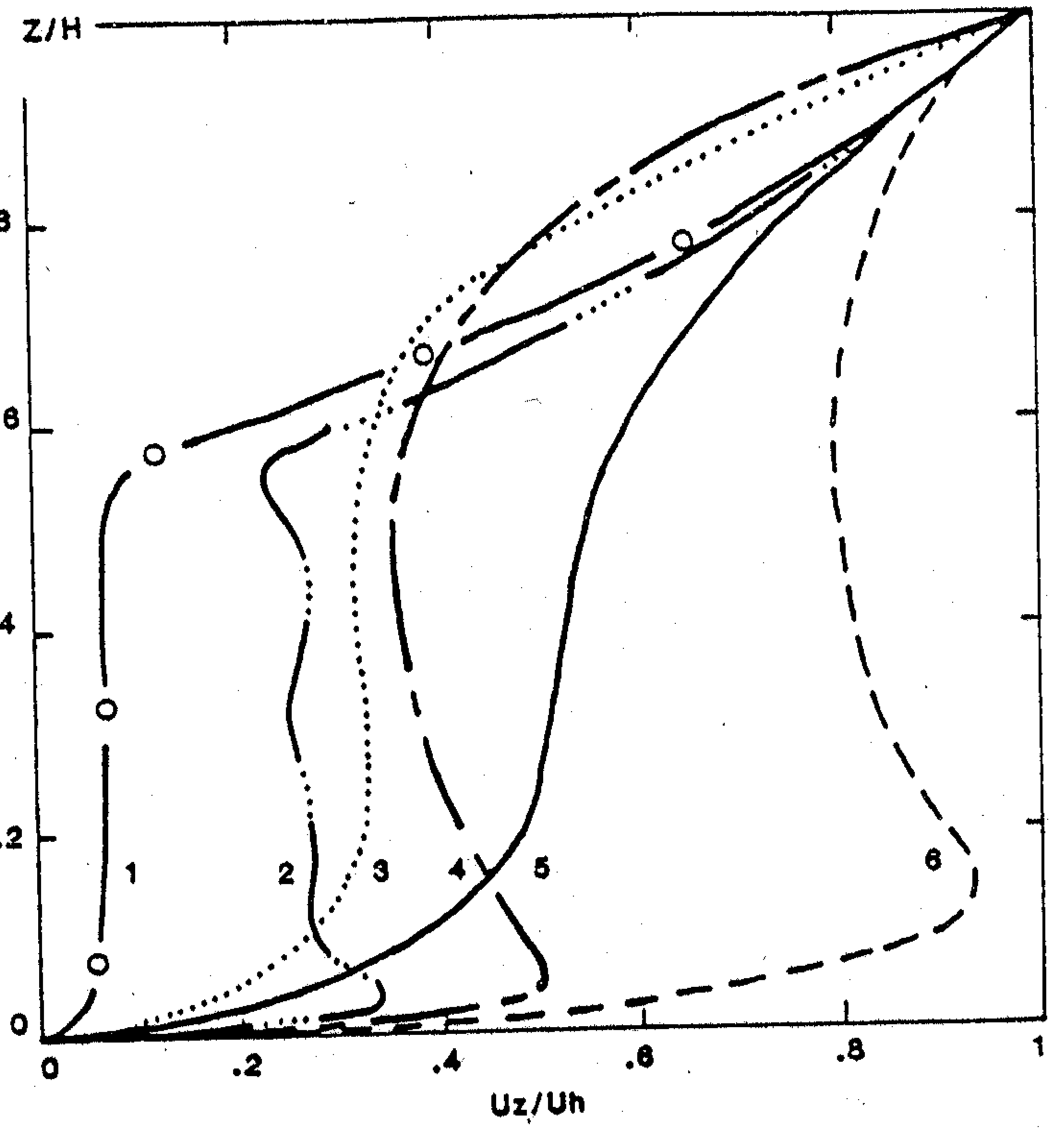
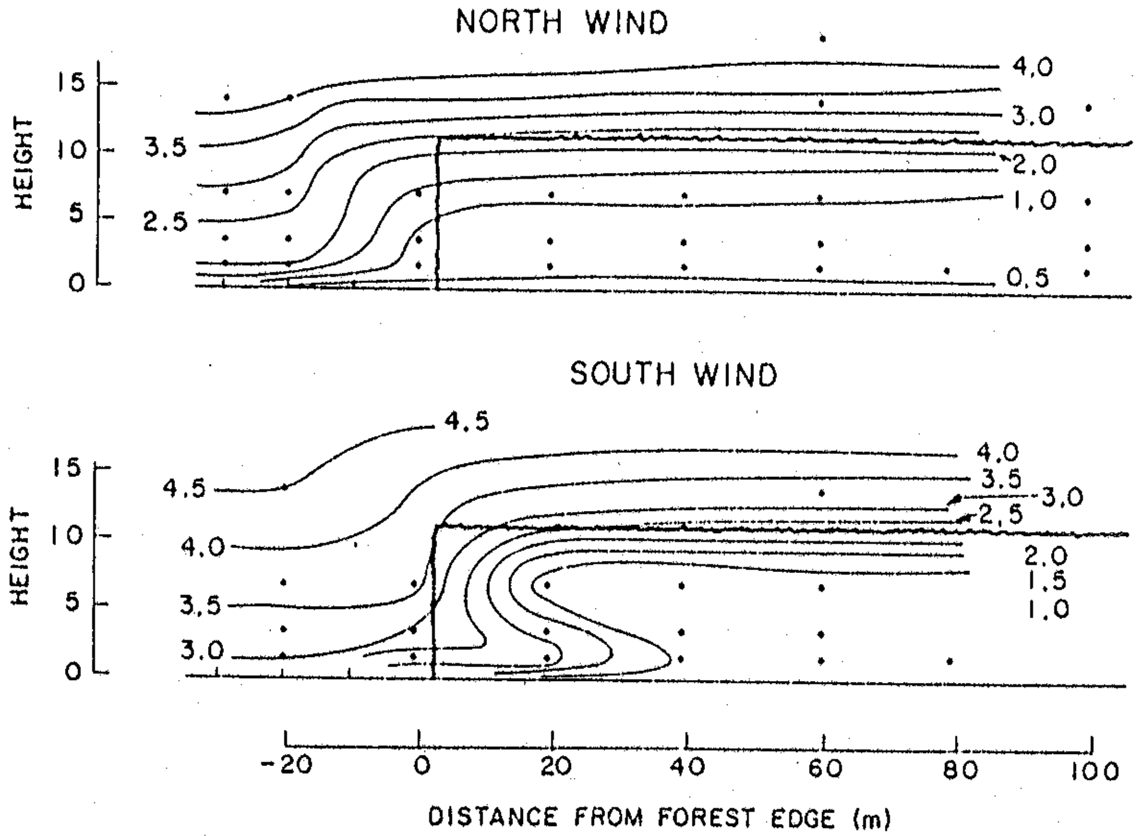


Fig. 3 . Wind profiles in a stand of pine for three ranges of wind speed.



igure 4. Comparison of normalized wind profiles of various egetative canopies where Z is the height above the ground, H is he height of the top of the canopy and U is wind speed. Line 1 s dense cotton (Fritschen, 1966); 2 is Douglas fir forest Fritschen et al., 1970); 3 is dense conifer with understory Gisborne, 1941); 4 is moderately dense conifer stand with no nderstory (Fons, 1940); 5 is dense hardwood jungle with understory (Latimer, 1950); and 6 is isolated conifer stand (Reifsnyder, 1955).



E 5. *Typical isopleths of wind speed in mps (meters per second) for winds with a long fetch ugh the forest (north wind) and winds into the forest edge (south wind). The squiggly line en- es the forest (average height, 10.5 m).*

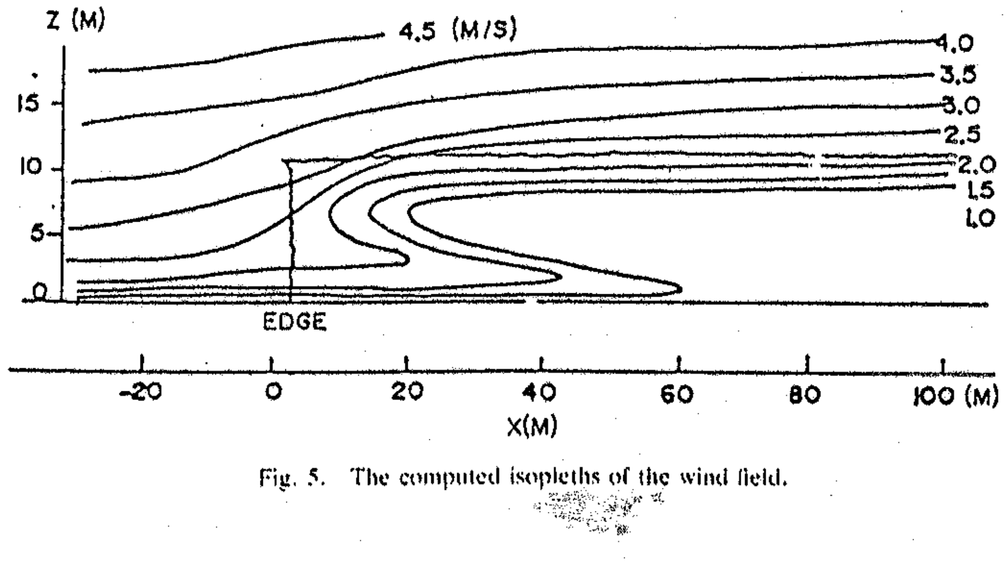


Fig. 5. The computed isopleths of the wind field.

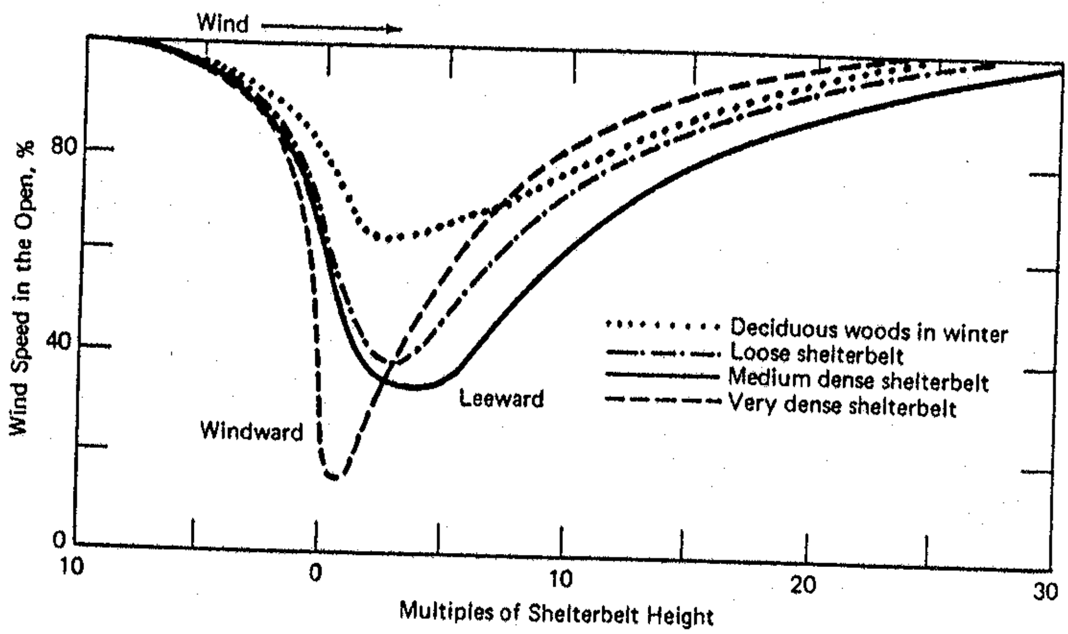


Fig. 6 Sheltering at different porosities, according to Nägeli (1941).

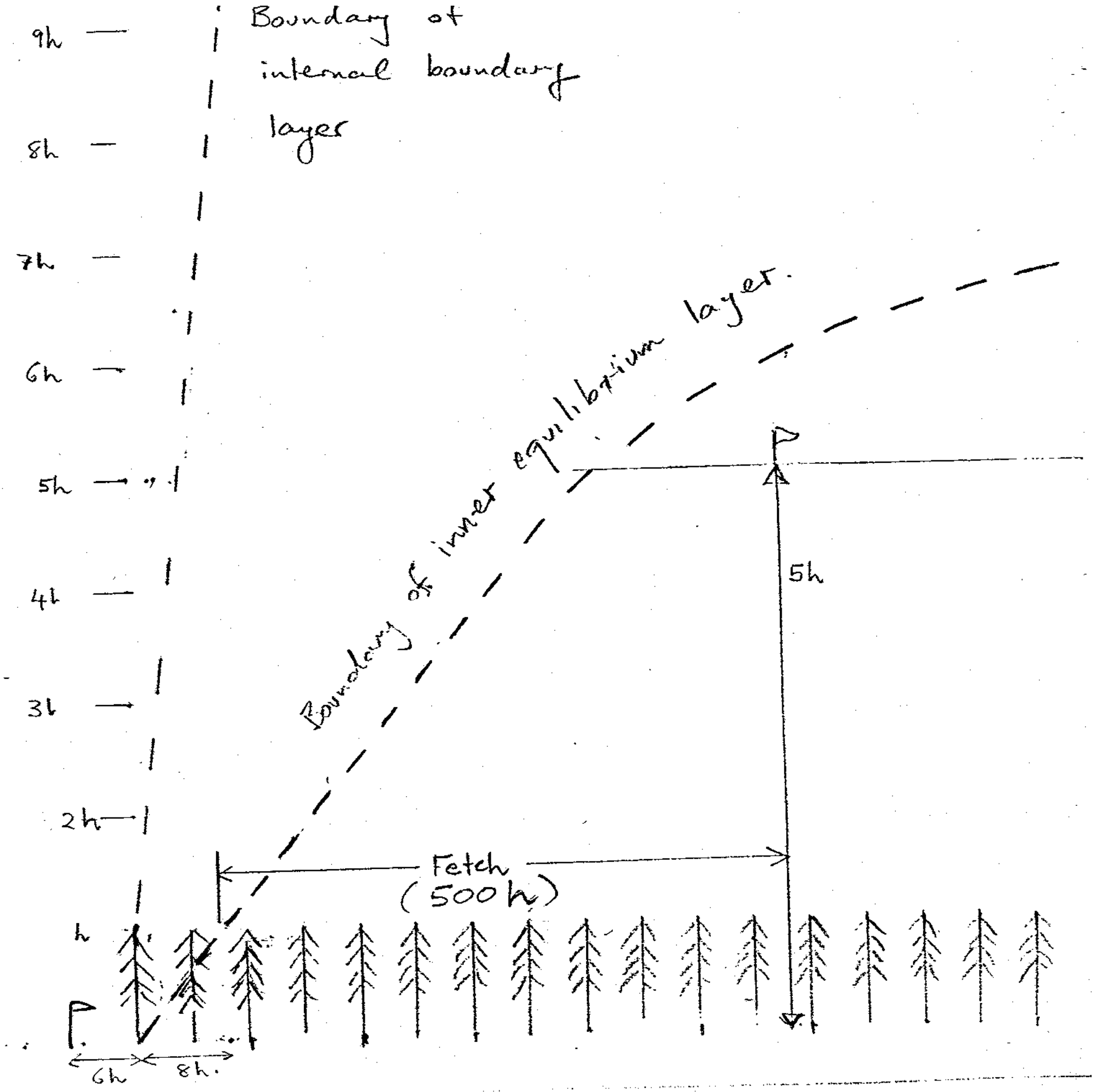

9h
8h
7h
6h
5h
4h
3h
2h
h
Boundary of internal boundary layer
Boundary of inner equilibrium layer.
5h
Fetch (500h)
6h
8h.

Fig 7

10 Appendix 1

Results of computerised literature search
on
wind, wind profiles and forests

1/3/1
37020195 ID NO.- MGA37020195
Zero-plane displacement and roughness length for tall vegetation, derived from a simple mass conservation hypothesis.
De Bruin, H. A. R.; Moore, C. J.
Royal Netherlands Met. Inst., De Bilt; Inst. of Hydrol., Wallingford, Eng.
Boundary-Layer Meteorology, Dordrecht, Holland, 31(1): 39-49, Jan. 1985. Refs., figs. DLC

1/3/2
36070403 ID NO.- MGA36070403
Climatology of wind profile parameter estimates above a growing pine forest.
Jaeger, L.
Met. Inst., Univ. of Freiburg, W. Germany
Archives for Meteorology, Geophysics, and Bioclimatology, Ser. B, Climatology, Environmental Meteorology, Radiation Research, Vienna, 34(1/2): 163-179, 1984. Refs., figs., tables, appendix. English and German summaries. DAS

1/3/3
32100342 ID NO.- MGA32100342
Wind profile and aerodynamic parameters above and within a plant canopy.
Kotoda, Kazuo
Japan. Tsukuba Univ., Inst. of Geoscience, Annual report No. 5, Dec. 25, 1979. p. 11-14. Refs.

1/3/4
30110299 ID NO.- MGA30110299
Turbulence measurements above a pine forest.
Thompson, N.
Met. Div., Chem. Defence Estab., Porton Down, Eng.
Boundary-Layer Meteorology, Dordrecht, Holland, 16(3): 293-310, May 1979. Refs. DLC

1/3/5
29060328 ID NO.- MGA29060328
Some measurements of the adiabatic wind profile over a tall and irregular forest.
Bergen, James D.
United States Forest Service. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO., General Technical Report RM-32, 1976. p. 116-121. Refs. DAS (A DS 11 A4567)

1/3/6
28100359 ID NO.- MGA28100359
Some measurements of the adiabatic wind profile over a tall and irregular forest.
Bergen, James D.
Rocky Mountain Forest and Range Experiment Station, USDA ForestServ., Ft. Collins, CO.
, National Conference on Fire and Forest Meteorology, 4th, St. Louis, MO., Nov. 16-18, 1976, Proceedings., [1976?]. p. 116-121. (USDA Forest Serv. General Technical Report RM-32)

1/3/7
27090284 ID NO.- MGA27090284
Wind profile estimates for a hardwood forest.
Singh, B.
McGill Univ., Montreal
McGill Univ., Montreal, Canada. Dept. of Geography, Climatological Bulletin No. 19, April 1976. p. 17-22. Refs.

1/3/8
24010115 ID NO.- MGA24010115
Kohlendioxydstrome und -Bilanz in einem Fichtenwald. Carbon dioxide flux and CO SUB 2 balance in a pine forest.
Von Paller, Heinrich
Munich. Universitat. Meteorologisches Institut, Wissenschaftliche Mitteilungen No. 21:14-16, May 1971.

1/3/9
23060361 ID NO.- MGA23060361
Vertical profiles of windspeed in a pine stand.
Bergen, James D.
U. S. Rocky Mt. Forest & Range Experiment Station, Ft. Collins, Colo.
Forest Science, Wash., D. C., 17(3):314-321, Sept. 1971.

1/3/10
20033202 ID NO.- MGA37090354
Estimations of surface roughnesses and displacement heights above a growing pine forest from wind profile measurements over a period of ten years.
Jaeger, Lutz
Dept. of Met., Freiburg Univ., W. Germany
In: Conference on Forest Environmental Measurements, Oak Ridge, TN., Oct. 23-28, 1983, Forest-atmosphere interaction: Proceedings. Dordrecht, D. Reidel Publ. Company, 1985. p. 71-90. Refs., figs. DLC (QK938.F6F66)

File(s) searched:

File 29:MET/GEOASTRO ABSTRACTS - 70-90/APR

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SAMPLE RECORD

The positions of the key fields are shown in the following sample record.

JA 27070509 ID NO.- MGA27070509
TI Influences des facteurs meteorologiques sur la variabilite de la magnesemie chez l'homme. [Influence of meteorological factors upon the changes in magnesium levels in man.]
AU Dariu, P.
CS Equipe de Biometrie Humaine du C.N.R.S., Paris, France
International Journal of Biometeorology, Amsterdam, 19(3): 166-173, Nov. 1975. Refs. DAS, DLC (QH543.Is)
LA LANGUAGE: fr
CP CTRY OF PUBL:NL
AB The magnesium level of the blood plasma and erythrocytes was studied in 24 human subjects for a one-year period. The data show that the magnesium levels are higher during the summer than during the winter. Whereas the erythrocyte magnesium concentration seems to be linked to the outside temperature, the plasma magnesium concentration seems to be sensitive to relative humidity and to sudden weather changes.
DE DESCRIPTORS: Weather effects on man; Biochemistry
(Copyright by the American Meteorological Society, 1984.)

Key to Data Fields

AB	Abstract	DT	Document Type
AU	Author	JA	Journal Announcement
CP	Country of Publication	LA	Language
CS	Corporate Source	TI	Title
DE	Descriptor		

Data present in record depends on output format requested and type of record.

DIALOG File 29: MET/GEOASTRO ABSTRACTS - 70-90/APR

37040066 ID NO.- MGA37040066
Zehn Jahre Niederschlagsmessungen uber einem Kiefernbestand im angehenden Stangenholzalter. [Ten years of precipitation measurements above a small pole wood pine stand, I.]
Jaeger, Lutz
Met. Inst., Univ. of Freiburg, W. Germany
Wetter und Leben, Vienna, 36(3): 149-158, 1984. Refs. English and German summaries. DAS, DLC
Language: ge
Country of Publication: AU
Within a long-term investigation concerning the energy balance of a pine forest, precipitation measurements were conducted. These precipitation records of the period 1974-1983 were compared with two stations of the German Weather Service which are recording the precipitation in the neighborhood of the forest. ,The author discusses the significance of the application of wind-shielded rain gages to estimate the precipitation above the rough forest surface. Also discussed are comparative measurements made with a normal Hellmann type rain gage and an ombrometer HP.
DESCRIPTORS: Rain-gage errors; Rain-gage comparisons; Forest rainfall; Federal Republic of Germany

35110532 ID NO.- MGA35110532
Radiation stress estimators.
Pawka, S. S.; Inman, D. L.; Guza, R. T.
Shore Processes Lab., Scripps Inst. of Ocean., Univ. of CA., La Jolla;
Journal of Physical Oceanography, Boston, 12(13): 1698-1708, Sept. 1983. Refs. DAS, DLC
Country of Publication: US
The radiation stresses, S SUB i SUB j , associated with the propagation of wind-generated waves are principal driving forces for several important surf-zone processes. The accurate estimation of the onshore flux of longshore- directed mean momentum S SUB y SUB x , by using a linear array of pressure sensors, is considered. Three analysis methods are examined: integration of two high-resolution directional-spectrum estimators (maximum likelihood (MLM) and a modified version (IMLM)) and a direct estimator of the S SUB y SUB x directional moment (DMM), developed in this study. The S SUB y SUB x estimation methods are compared by using numerical simulations and field data from two experiments at Torrey Pines Beach, CA. In the first field experiment, IMLM and DMM, estimates of S SUB y SUB x (from a three-element, 99-m-long linear array) showed excellent agreement with a slope array (Higgins et al., 1981) in the frequency range 0.06-0.15 Hz. In the second experiment, IMLM and DMM SUB v estimates of S SUB y SUB x (from a five-element, 360-m-long array) agreed with values of S SUB y SUB x obtained from a nearby orthogonal-axis current meter for the frequency range 0.06-0.11 Hz. The integration of the MLM directional spectrum estimates yields biased (low) values of S SUB y SUB x . Although the DMM method is used here for the estimation of S SUB y SUB x , it can easily be adapted for the calculation of any arbitrary directional moment. While conventional methods are shown to be deficient in S SUB y SUB x estimation, they provide accurate estimates of S SUB x SUB x , the onshore flux of onshore-directed momentum.
DESCRIPTORS: Wind wave propagation; Shallow water waves; Surf zone dynamics

35070144 ID NO.- MGA35070144
Experimental and theoretical investigation of the dry deposition of particles to snow, pine trees, and artificial collectors.
Ibrahim, M.; Barrie, L. A.; Fanaki, F.
Atmos. Environ. Serv., Downsview, Canada;
Atmospheric Environment, Oxford, 17(4): 781-788, 1983. Refs., tables. DAS, DLC (TD881.A8)
Country of Publication: UK
Submicrometer and supermicrometer ammonium sulfate particles tagged with the radioisotope S-35 were released upwind of natural snow, trees and artificial collectors in a large field containing micrometeorological and air monitoring equipment. At a reference height of 10 cm, the average deposition velocity for 0.7- MU m diameter particles was observed to be 0.039 and 0.096 cm sec SUPER - SUPER 1 in two experiments conducted at a wind speed of 2.7 and 2.4 m sec SUPER - SUPER 1 under stable and unstable conditions, respectively. Supermicrometer particles having an effective diameter of 7 MU m were deposited to snow at a rate of 0.16 and 0.096 cm sec SUPER - SUPER 1 in two experiments conducted under unstable conditions at a wind speed of 2.4 m sec SUPER - SUPER 1 . Compared to snow, all artificial collectors used in this study undercollected submicrometer particles and overcollected supermicrometer particles. Individual white pine branches scavenged submicrometer particles with an average efficiency of 0.015%. Comparisons of the theoretical and observed deposition rates of submicrometer particles to snow suggest that hygroscopic growth of sulfate particles in the humid near-surface snow layer and interception by ice needles play a role in the deposition process.
DESCRIPTORS: Particle deposition; Aerosol deposition; Atmospheric pollution deposition

34110443 ID NO.- MGA34110443
Comparisons of interception loss from tropical and temperate vegetation canopies.
Lockwood, J. G.; Sellers, P. J.
School of Geog., Univ. of Leeds, Eng.;
Journal of Applied Meteorology, Boston, 21(10): 1405-1412, Oct. 1982. Refs. DAS, DLC
Country of Publication: US
A multilayer crop model is used to investigate interception loss from oak, pine, wheat, and grass canopies. It is shown that the evaporative properties of the full oak canopy are similar to those of the evergreen tropical rain forest. Evaporation from all the wet canopies is shown to be similar
(cont. next page)

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at low wind speeds, but the loss from the tree canopies increases rapidly with increasing wind speed. In the low-wind-speed equatorial environment, it would seem likely that changing vegetation type would cause little difference in interception loss and, therefore, runoff. Equatorial observations suggest that this is not so, and the reasons for this are discussed. Possible hydrometeorological consequences of the deforestation of the Amazon basin are also considered.
DESCRIPTORS: Precipitation interception by forests; Precipitation interception by plants; Water loss investigations; Forest effects on runoff

33110257 ID NO.- MGA33110257
Studies on the windbreak nets, Pt. 3, Horizontal and vertical turbulent characteristics influenced by two kinds of windbreak nets in a paddy rice field.
Maki, Taichi
Div. of Met., Natl. Inst. of Agri. Sci., Ibaraki-ken, Japan
Journal of Agricultural Meteorology, Tokyo, 37(3): 197-210, Dec. 1981. Refs., figs. Japanese summary. For abstract of Pt. 2, see Met. Abs., 32.8-330. DAS
Country of Publication: JA
The horizontal variations and vertical profiles of various turbulent characteristics for two kinds of windbreak nets were obtained by the use of an ultrasonic anemometer from -20 H windward (distance expressed as a multiple of the net height, H = 2 m, and negative signal denoting the windward) to 40 H leeward at 50- to 250-cm heights in the paddy rice field. The turbulent intensity increased slightly at an immediate windward from the net (-0.25 H), took, respectively, the minimum and the maximum around an immediate leeward (1-2 H) and at 10 H, and gradually decreased for farther distances. The magnitude of turbulent intensity in the leeward for the net was much smaller than that for the pine windbreak forest and other fences, which expresses the characteristic of the net. The horizontal variation of the dissipation rate of turbulent energy was similar to that of turbulent intensity; however, the largest and smallest eddies and the characteristic time scales of autocorrelation coefficients and their ratios were almost contrary in relation to turbulent intensity. The turbulent characteristics at a height of 100 cm returned to the windward ones by 30 H for cheese cloth net and by 20-25 H for polyethylene russell net, but at a height of 50 cm, the recovery took longer distances. The vertical profiles of turbulent characteristics were generally smooth at -20 H, but rather irregular at 2 and 5 H. This paper made clear the turbulent characteristics of airflow over the net at a height of 250 cm at 2 and 5 H, of the wind passed through the net at heights of 100 and 150 cm, and of the upward wind passed through the open space under the net at a 50-cm height at 2 H. The turbulent intensity and energy dissipation rate were larger at the upper levels, but the largest and smallest eddies and the characteristic time scales of autocorrelation and their ratios became smaller at those levels.
DESCRIPTORS: Windbreak effects on turblence

33030434 ID NO.- MGA33030434
Glaciation of the east slope of Rocky Mountain National Park, Colorado.
Richmond, Gerald M.
In: Ives, Jack D. (ed.), Geoecology of the Colorado Front Range: a study of alpine and subalpine environments. Boulder, CO., Westview Press, 1980, p. 24-34. Refs. DLC (QE92.F5G46). Reprinted from Geological Society of America, N.Y., Bulletin, Vol. 71, 1960, p. 1371-1382. DLC
Country of Publication: US
The eastern slope of Rocky Mts. National Park, CO., was subjected to at least three separate Pleistocene glaciations, which, from oldest to youngest, are correlated with the Buffalo, Bull Lake, and Pinedale glaciations of Blackwelder in the Wind River Mts., WY. In this area, deposits of the oldest glaciation are known from only one locality. Deposits of the Bull Lake glaciation comprise two sets of moraines indicative of two advances of ice which were separated by a significant recession; those of the Pinedale glaciation comprise three sets of moraines indicative of a maximum advance of the ice and two recessional halts or minor readvances. Moraines of two minor advances of the ice, correlated with the Temple Lake and historic stades of neoglaciation in the Wind River Mts., occur in the cirque heads.
DESCRIPTORS: Glacial periods; Glacial period moraines; Rocky Mts. National Park, Colorado

32100352 ID NO.- MGA32100352
Surface wind structure in forest clearings during a chinook.
Swanson, Robert H.
Forest Hydrology Res. Canadian Forestry Serv., Edmonton, Alberta
, Western Snow Conference, Annual Meeting, 48th, Laramie, WY., April 15-17, 1980, Proceedings. Ft. Collins, CO., Colorado State Univ. [1980]. p. 26-30. Refs. DAS (A QC 929 S7W4)
Country of Publication: US
During a chinook wind period, April 6-8, 1979, horizontal wind speed and its vertical component at a 2-m height were measured in 12 circular clearings, 1 to 6 tree heights in diameter in a 20-m tall lodgepole pine forest in Alberta. These values were compared with horizontal wind speed in the center of a 400 MULTIPLIED BY 400- m clearcut and at 10 m above the tree canopy. Wind speed in all of the small circular clearings averaged about 1/20 of that above the canopy; that in the clearcut square was approximately equal. Vertical motion in 4- and 6-tree height clearings was four times that in the smaller ones.
DESCRIPTORS: Chinook winds; Wind field in forests; Alberta, Canada

DIALOG File 29: MET/GEOASTRO ABSTRACTS - 70-90/APR

32080120 ID NO.- MGA32080120
Mechanisms of trace element deposition from the free atmosphere to surfaces in a remote High Sierra canyon.
Elias, Robert W.; Davidson, Cliff
Dept. of Biol., VA. Polytech. Inst., Blacksburg; Dept. of Civil Engr., Carnegie-Mellon Univ., Pittsburgh, PA.
Atmospheric Environment, Oxford, 14(12): 1427-1432, 1980. Refs. DAS, DLC (TD881.A8)
Country of Publication: UK
Field experiments to determine size distributions and deposition rates of airborne K, Rb, Cs, Ca, Sr, Ba, and Pb were conducted in Thompson Canyon, CA. (elevation 3000 m) during 1976 and 1977 in order to study deposition mechanisms at this remote site. The data suggest that sedimentation accounts for most of the deposition of the first six elements on smooth, flat surfaces in winds of 2 m sec SUPER - SUPER 1, but that turbulent inertial deposition becomes more important at greater wind speeds. Pb is found in smaller particle sizes and is less influenced by sedimentation. The data and associated calculations also suggest that inertial impaction plays a dominant role in transporting these elements to pine needle surfaces in the canyon.
DESCRIPTORS: Atmospheric pollution deposition; Particle deposition; Thompson Canyon, California

32060463 ID NO.- MGA32060463
Compilation of agro bioenvironmental maps of Southeast Asiatic countries.
Sekiguti, T.
Japanese Progress in Climatology, Tokyo, 1979. pub. March 1980. p. 1-21. DAS
Country of Publication: JA
The authors have summarized the natural conditions favorable to the cultivation of tropical agricultural resources and have compiled various research results and textbooks, which show the location of potentially cultivable lands with favorable climatic conditions (as seen on maps with a scale of 1:1 million). The criteria considered important are rainfall, temperature, insolation and sunshine duration, wind conditions, and soil conditions. The optimum conditions for tropical crops are identified, and the maximum yield is evaluated. The major crops investigated were paddy rice, maize, sorghum, beans, ground nuts, cassava, taro, sago palm, sugar cane, coconut palm, oil palm, castor oil plant, banana, pineapple, cashew nuts, coffee, cacao, tea, tobacco, green pepper, red pepper, cotton, kapok, jute, kenaf, roselle, and Para rubber.
DESCRIPTORS: Agroclimatic conditions; Tropical agriculture; Southeast Asia

32010340 ID NO.- MGA32010340
Some energetic effects of forest interception.
Tajchman, Stanislaw J.; Boyer, Douglas G.
Div. of Forestry, W. VA. Univ., Morgantown;
Munich. Univ., Meteorologisches Institut, Wissenschaftliche Mitteilung No. 35, Nov. 1979. p. 83-86. Refs. DAS, DLC
Country of Publication: GE
The energetic effects of a forest on intercepted water, which involve the reciprocal dependence between evapotranspiration and interception, were investigated in a young pine stand. In addition to interception loss, the measurements included dry and wet bulb temperature, wind speed and radiation above the canopy, and soil temperature. Latent and sensible heat fluxes were calculated by Sverdrup's method. The ratio DELTA THETA / DELTA q was calculated by the least square method; THETA is potential temperature, and q is specific humidity. The Bowen ratio (BETA) and relative evapotranspiration are represented graphically. The results indicate that the interception loss varied with distance from the rows of trunks, reaching a minimum in the center (between the rows) and a maximum in the center of the crown area. The latent heat of evapotranspiration was 1.6 times greater than the energy supplied by net radiation. The shortfall in energy was in the form of sensible heat.
DESCRIPTORS: Precipitation interception by forests; Energy balance of forests

32010106 ID NO.- MGA32010106
Atmospheric natural hydrocarbon concentrations in the Adirondack, New York, area.
Mohnen, V. A.; Roland, L.
Atmos. Sci. Res. Ctr., N.Y. Univ. at Albany;
American Geophysical Union, Wash., D.C., EOS: Transactions, 60(18): 266, May 1, 1979. Abstract only. (Spring Meeting Program, Wash., D.C., May 28-June 1, 1979). DAS, DLC
Country of Publication: US
Measurements of the natural hydrocarbons-in particular, ALPHA , BETA -pinene, p-cymene, and d-limonene-in the Adirondack Mts, N.Y., have been made over the past two years. During the entire winter season (from November through April), the ambient natural hydrocarbon concentration is below the detection limit, i.e., less than 80 p.p.t., coinciding with the lack of photosynthetic production by plants. The concentration ratio between p-cymene, d-limonene, and ALPHA -pinene is approximately 6:2: 1/2 . BETA -pinene was detected only in early summer at levels of APPROX. 5 MU g/m SUPER 3 , while ALPHA -pinene concentrations remained at levels of 5-10 MU g/m SUPER 3 throughout the summer. The p-cymene concentration levels are typically between 20 and 100 MU g/m SUPER 3 , and the range of d-limonene are APPROX. 10-50 MU g/m SUPER 3 . The concentration fluctuations from day to day are substantial and, on some days, even approach the instrument's lowest detection limit. Simultaneous measurements of meteorological parameters (wind and solar radiation), ozone, and total suspended particulates are used to discuss the potential implications of the natural hydrocarbons on the atmospheric chemistry of the general area.
DESCRIPTORS: Hydrocarbons in air; Adirondack Mts., New York

DIALOG File 29: MET/GEOASTRO ABSTRACTS - 70-90/APR

31090574 ID NO.- MGA31090574
Local and shoaled comparisons of sea surface elevations, pressures, and velocities.
Guza, R. T.; Thornton, Edward B.
Shore Processes Lab., Scripps Inst. of Ocean., Univ. of CA., La Jolla; Naval Postgrad. School, Monterey, CA.
Journal of Geophysical Research, Wash., D.C., 85(C3): 1524-1530, March 20, 1980. Refs. (Paper 9C1668). Reprint available from American Geophysical Union, Wash., D.C. 20009. DAS, DLC
Country of Publication: US
Sea surface elevations, or pressures, and velocities were measured at closely spaced (wavelength or less) locations in a line extending from a 10-m depth to locations inside the surf zone at Torrey Pines Beach, San Diego, CA. Intercomparisons of local pressure, velocity, and sea surface elevation spectra for the wind wave frequencies (0.05-0.3 Hz) were made by using linear wave theory. Errors in both total variance and energy density in a particular frequency band are less than 20% both inside and outside the surf zone, except in the immediate vicinity of the breakpoint, where larger disparities are observed. Surface elevation spectra calculated at 10 m were shoaled by using linear wave theory. The total variance of stations between 10- and 3-m depth is typically predicted with less than 20% error, although harmonic amplification and other nonlinear effects can lead to significant errors in prediction at particular frequency bands. Observations inside 3-m depth significantly departed from the predictions of linear shoaling theory.
DESCRIPTORS: Shoaling waves; Surf zone regime; Coastal Waters of West U.S.

31050460 ID NO.- MGA31050460
Particularitatile bioclimatice ale zonei alpine din Muntii Cindrel (Carpatii Meridionali) (1750- 2244 m). [Bioclimatic characteristics of the mountainous zone in the Cindrel Mountains (southern Carpathians) (1750-2244 m).]
Fesci, Simona.
Studii si Cercetari, partea 1, Meteorologie, Bucharest, 1978. p. 619-635. Refs. English and French summaries.
Language: ro
Country of Publication: RO
This paper deals with the topo- and microclimatic influence of the mountainous regions upon the phenology and behavior of insects and vegetation. The insects were chosen as representatives of time and space climatic factors because they are closely related to the vegetal forms. The knowledge of their relationship with vegetation and clime has an ecological significance in times of complex exploitation of all parcels of land. The topo- and microclimatic observations were concerned with the solar radiation, temperature and relative air humidity (at the ground level and at 1, 1.50, and 2 m height); the soil temperature (at 4 and 10 cm depth, respectively); the precipitation; wind direction and speed of the dominant air currents; and the general atmospheric state. The investigations were performed in typical ecosystems (plateaus, peaks, slopes, and ice circles) of various altitudes, orientations, and sheltering degree. In specific light conditions of the mountainous region with its two divisions, subalpine (1750-2000 m) and Alpine (2000-2244 m), two essential factors contribute to the distribution of the biogeographical mozaic: the angle and orientation of the slope. The flatness and continuity of the Borascu plateau in the Cindrel Mountains explain the uniform topoclimate on the background of slopes open to Sun radiation. The vegetation is differentiated as far as the ecophysiological requirements are concerned with regard to the environment, in general, and to clime, in particular. The northern slopes are mainly covered with mountain pines (Pinus mugo), whereas the northwestern ones are covered with rhododendrons (Rhododendron kotschyi) to 1950- m height. Beyond this altitude, the phytocenosis passes over the southern slopes; the juniperets (Juniperus sibirica) are generally located along the southern slopes, reaching as far as below the rhododendrons belt; and the vaccinites prefer the shadow slopes. The lawn vegetal associations observe the same requirements as the shrubbery. The time and space fluctuations of the climatic elements determine differences in the phenology of the organisms. The divided blossoming of the phytocenosis can be noticed for the large insect populations. Different climatic years leave an impact on the associations of vegetals and animals. Weather conditions influence the appearance and activity of insects.
DESCRIPTORS: Mountain bioclimatology; Mountain ecology; Mountain microclimatology; Topoclimatology; Cindrel Mts., Carpathian Mts., Europe

31050444 ID NO.- MGA31050444
Approach to the understanding of the summer climate 7000-6000 B.P. in Ryfylke, southwest Norway.
Selsing, Lotte; Wishman, Erik Hauff
Arkeologisk Museum, Norway;
Denmark. Meteorologisk Institut, Copenhagen, Klimatologisk Meddelelser No. 4, 1978. p. 146-153. Refs., figs. DAS (A QC 989.D4D45)
Country of Publication: DA
Archaeological findings in Ryfylke, southwest Norway, indicate that the mesolithic hunting culture had used the mountain areas around the 1000-m mountain level only during 7000-6000 yr B.P. The confinement of the use of this area solely to the 7000-6000-yr B.P. period is investigated by examining the pine forest limit in this period. The temperature characteristics of the mean atmosphere pressure of the fjord districts for this period are deduced, and the probable circulation types during the Atlantic summer season are determined. It is suggested that, during the period of occupation of the area, cyclones with rain and wind from the west must have occurred relatively frequently. The oceanic airmasses must have been warmer (and moister) than in this climatic period.
DESCRIPTORS: Historic climates; Ryfylke, Norway

30120380 ID NO.- MGA30120380
Solar luminosity and the sun-spot cycle.
Dicke, R. H.
Joseph Henry Labs., Phys. Dept., Princeton Univ., N.J.
Nature, London, 280(5717): 24-27, July 5, 1979. Refs., figs. DAS, DLC
Country of Publication: UK
The statistically strongest indication of a sharply tuned, 22-yr period in a climate indicator is that found by Epstein and Yapp in the [D/H] abundance ratios measured in the cellulose extracted from two bristle- cone pine trees that together span 1000 yr. If the 22.36-yr periodicity is meaningful, its correspondence with the period of the sun-spot cycle suggests a close relationship with the solar cycle. If the solar cycle is the driving force in this periodicity of D, neither sun-spots, faculae, flares, other solar activity, nor the solar wind can be responsible for the 22-yr cycle; these surface phenomena exhibit the large-phase fluctuation, whereas this phase fluctuation is not present (at a 1 SIGMA significance level) in D. A periodically varying luminosity of the Sun is suggested as a feasible source of variation in climate, but the variation must be induced in the deep interior of the Sun, probably toward the bottom of the convective zone and magnetic fields. The Epstein-Yapp indicator D and the sun spot numbers R are consistent with the assumptions: 1) that filtered [D/H] data, D, monitors a 22-yr luminosity variation of the Sun; 2) that the luminosity is modulated by a deeply buried, magnetofluid dynamic oscillator associated with solar phenomena; 3) that some part of this magnetic field floats slowly to the surface where, years later, it is responsible for solar activity; and 4) that the magnetic field arrives at the surface APPROX. 13 - 0.041 (< R > -91.4) yr after the modulation of the luminosity < R > is evaluated at the time of arrival at the surface. Computations are presented, showing increases in luminosity at times of temperature maxima 1891.0, 1913.3, 1936.7, and 1958.0, during 1968 to 1978 of 0.4%, corresponding to an amplitude of the 22-yr period of 0.24% etc.
DESCRIPTORS: Solar-climate relationships; Twenty-two-year solar cycles; Solar luminosity

30010114 ID NO.- MGA30010114
Model for predicting synoptic weather types based on model output statistics.
McCutchan, Morris H.
Pacific Southwest Forest and Range Experiment Station, Forest Serv.,U.S. Dept. of Agri., Berkeley, CA.
Journal of Applied Meteorology, Boston, 17(10): 1466-1475, Oct. 1978. Refs. DAS, DLC
Country of Publication: US
An objective classification model was developed which can automatically predict synoptic weather types in southern California. Stepwise discriminant analysis was used to match the National Meteorological Center's Limited- area Fine Mesh (LFM) Model Output Statistics to subjectively classified weather types or patterns. The five classified weather types range from hot, dry, windy Santa Ana days to cool, rainy, cloudy days caused by a synoptic low. Discriminant function equations were developed for predicting each weather type 12 and 24 hr in advance by screening 80 potential predictors consisting of forecasts at 500, 700, and 850 mb from the LFM model. Model output at nine grid points was used because that information describes adequately the meteorological patterns over southern California. By using independent LFM model forecasts valid 12 and 24 hr in advance, the objective classification model predicted the probability of the days being in each of the five weather types, then the type with the highest probability was selected. Eighty-eight of 107 24-hr periods (days) centered 12 hr in advance (81%) were correctly predicted. Of 99 independent days centered 24 hr in advance, 71 (72%) were correctly predicted. Hourly means and standard deviations of surface temperature and dew points at eight research sites in the San Bernardino Mountains, computed by month for the five weather types, had distinct diurnal variations corresponding with weather types. Summarizing hourly temperatures in Aug. at the eight sites by weather type reduced their standard deviation by almost one half. Measurements of mean daily maximum ozone at a San Bernardino Mountain crest site, where chronic ozone injury to ponderosa pine has occurred, showed significant differences between the weather types. The mean surface wind, temperature, and dew-point patterns at 2100 hr GMT over southern California for type-1 (Santa Ana) days show strong offshore winds, high temperatures, and low dew points, whereas type-5 (synoptic low) days show strong onshore winds, low temperatures, and high dew points.
DESCRIPTORS: Short-range forecasting techniques; Objective forecasting methods; California, United States

29070009 ID NO.- MGA29070009
Preprints.
National Conference on Fire and Forest Meteorology, 5th, AtlanticCity, N.J., March 14-16, 1978
Cosponsored by the American Meteorological Society and the Society of American Foresters. Boston, American Meteorological Society, [1978]. 99 p. Refs. Unrefereed papers. For abstract on 4th National Conference, see Met. Abs., 29.6-7.
Country of Publication: US
Harrington, James B. and Donnelly, Robert E., Fire probabilities in Ontario's boreal forest, p. 1-4. Haines, Donald A. and Main, William A., Variation of six measures of fire activity associated with drought, p. 5-7. Furman, R. William, Drought analysis for planning, p. 8-10. Furman, R. William, Meteorological data collection and natural resource planning, p. 11-12. Murphy, C. E., Jr., Schubert, J. F. and Dexter, A. H., Bowen ratio estimates of pollutant deposition velocity in a pine forest, p. 13-16. Droppo, J. G., Revised method of computing energy balances over vegetation canopies, p. 17-19. Howard, E. A., III, Simple model for estimating the moisture content of living vegetation as potential wildfire

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fuel, p. 20-23. Running, Steven W., Process oriented model for live fuel moisture, p. 24-28. Wilson, N. Robert, Numerical simulation of airflow in forested environments, p. 29-31. Fuquay, Donald M., Predicting ignition of forest fuels by lightning, p. 32-37. Sommers, William T., On forecasting strong mountain downslope winds, p. 38-43. Brotak, Edward A., Low-level wind and temperature profiles associated with major wildland fires, p. 44-47. Renne, David S., Comparison of atmospheric stability between a valley and mountain site, p. 48-51. Roussopoulos, Peter J., Decision aid for wilderness fire prescriptions in the boundary waters canoe area, p. 52-58. Johnson, Von J. and Main, William A., Climatology of prescribed burning, p. 59-62. Miller, Roswell K., Keetch-Bryam drought index and three fires in upper Michigan, 1976, p. 63-67. Vance, Dale L. and Krider, E. Philip, Lightning detection systems for fire management, p. 68-70. Paul, James T., Forestry weather interpretations system (FWIS)- a cooperative experiment in weather for forestry, p. 71-78. Holbo, H. R., Corbett, T. C. and Horton, P. J., Wind-induced motions of individual Douglas-fir in stands, p. 79-83. Miller, James R., Jr. and Halligan, Don K., Some aspects of the snow damage to the Black Hills Forest 26-27 April 1976, p. 84- 87. Lavdas, Leonidas G., Plume rise from prescribed fires, p. 88-91. Mobley, Hugh E., Application of smoke management research in the South, p. 92-93. Martin, Robert E., Prescribed burning: decisions, prescriptions, strategies, p. 94-99.
DESCRIPTORS: Forest meteorological conferences; Fire weather conferences

29030401 ID NO.- MGA29030401
Frost damage increased by the windbreak.
Mihara, Y.; Tsuruta, K.; Nemoto, O.
Coll. of Horticulture, Chiba Univ., Japan;
Journal of Agricultural Meteorology, Tokyo, 33(2): 67-74, Sept. 1977. In Japanese; English summary.
Language: other
Country of Publication: JA
A large orchard of satsuma mandarin located near the seacoast of the southern end of Kyushu was completely destroyed by the early frost on two successive nights in Nov. 1968. The 72-ha orchard in an artificially flattened dune, 5 m a.s.l., is divided into 60 rectangular sections; each section, 100 m wide and 120 m long, is surrounded by a pine tree hedge 6-8 m high and is partitioned into nine small parts by 1.8-m high plastic- net windbreaks set up in two lines and two rows. Under such a perfect protection against wind hazard, about 200,000 young mandarin trees were planted in the autumn of 1967 and the spring of 1968. In Sept. 1968 a typhoon, passing off the sea coast to the north, swept the orchard; however, wind hazard was slight, only faint discoloration was recognized on leaves during a few weeks after the typhoon. Unusual severe frost occurred on Nov. 15 and 16, after a warm spell of about ten days. Nearly 85% of mandarin trees in the orchard were injured; most of their trunks were frozen to death. Thus, the orchard was destroyed and abandoned one year after establishment. Severe damage caused by the early frost, however, was restricted within the orchard with windbreaks on the dune. Significant hazard was light in many other orchards on the hillsides adjacent to the destroyed one. To find out why the frost damage was so severe in the orchard protected by windbreaks, observations were done for several nights in the ruined orchard and on flat ground with model windbreaks. It is concluded that the night land breeze, generally called cold-air flow, lessens in reality the night chilling of the air near the ground surface, and that obstruction to the breeze by windbreaks will cause extreme coldness on the leeward side of the windbreaks on nights when radiation cooling occurs.
DESCRIPTORS: Frost damage to orchards; Shelter belt effects on frost damage; Orchard damage by frost; Kyushu, Japan

28080328 ID NO.- MGA28080328
Local climatological observations in the Atsumi Peninsula, Aichi Prefecture, central Japan, Pt. 1.
Owada, Michio; Kushioka, Yoichiro
Dept. of Geog., Aichi Univ. of Education, Kariya City, Aichi ; Nomi Primary School, Toyota City
Journal of Agricultural Meteorology, Tokyo, 32(4): 195-201, March 1977. Refs. In Japanese.
Language: other
Country of Publication: JA
Wind shaped pines were used to study the prevailing summer (southerly) winds and winter (northerly) winds and their topographical distribution on the Atsumi Peninsula of Central Honshu, as shown on four detailed charts of the area. A topographical map also shows the eleven observation points where salinity was measured along a cross section from Ehima on one coast to Akabane on the other side of the Peninsula. The salinity in p.p.m., as salt adhering to gauze, is shown on a cross-section chart, varying from 80 p.p.m. on the windward coast to about 20 on the leeward. The text is all in Japanese, but captions for illustrations are in English.
DESCRIPTORS: Prevailing wind; Wind distribution; Salinity distribution; Philippine Sea; Atsumi Peninsula, Japan

28050425 ID NO.- MGA28050425
Eddy flux measurements above a pine forest.
Moore, C. J.
School of Earth Sci., Flinders Univ. of S. Australia
Royal Meteorological Society, Bracknell, Eng., Quarterly Journal, 102(434): 913-918, Oct. 1976. DAS, DLC
Country of Publication: UK
Estimates of sensible and latent heat flux measured above a Pinus radiata forest plantation, 11 km north of Mt. Gambier in South Australia, by eddy-correlation instrumentation, were found to satisfy the forest energy budget to within 20%, provided the mean windspeed was greater than about 2 m sec SUPER - SUPER 1 . In lighter winds, these two fluxes were severely underestimated. A study of the higher wind speed

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data, when the forest canopy was externally dry and transpiration the only water loss, gave a Bowen ratio of 0.8 PLUS OR MINUS 0.1 during the day, with a diurnal trend similar to that for shorter vegetation types. In these conditions, the hourly change in canopy heat storage was a significant component of the energy budget. When the canopy was wet from intercepted rainfall, the Bowen ratio was generally less than 0.3 and often negative. Incoming sensible heat and a cooling canopy provided energy for evaporation when the net radiation was low or negative.
DESCRIPTORS: Forest micrometeorology; Energy balance of forests; Heat flux over forests; South Australia, Australia

28030190 ID NO.- MGA28030190
Windspeed distribution in and near an isolated, narrow forest clearing.
Bergen, James D.
Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.
Agricultural Meteorology, Amsterdam, 17(2): 111-133, Aug. 1976. Refs. DAS, DLC (600.A34)
Country of Publication: NL
Windspeeds were measured on a three-dimensional array in and near a 10- by 50-m clearing cut in a 10-m high lodgepole pine stand. Measurements made while the wind direction above the canopy was perpendicular to the long axis of the clearing are used in a continuity calculation to establish the velocity field for the flow in and downwind of the clearing. The ratio of the local speed to the estimated above-canopy friction velocity is approximately independent both of the latter and of the above-canopy stability. Minimum speeds occur at the clearing center and at the midcrown region on the lee edge of the clearing. Speed maxima occur at sub canopy levels on either edge and above the lee edge. Clearing effects extend behind the clearing to at least 25 m, but are only slightly apparent upwind of the clearing. The continuity calculation indicates a separation of the flow beginning at the mid-clearing floor and extending to the upper surface of the lee canopy. Reattachment occurs 4 or 5 m behind the lee clearing edge, with strong reverse flow apparent upwind from that point. An approximate analysis of the flow is made in terms of a penetrating inviscid jet model presented by previous authors and an adaptation of a solution for an inviscid jet impinging on a screen. Agreement with the observed flow pattern is fair.
DESCRIPTORS: Airflow in forests; Forest winds

28020472 ID NO.- MGA28020472
Canopy of a Scots pine forest: description of a surface of complex roughness.
Ford, E. D.
Inst. of Terrestrial Ecology, Bush Estate, Midlothian, Scotland
Agricultural Meteorology, Amsterdam, 17(1): 9-32, July 1976. Refs. DAS, DLC

Country of Publication: JA
Extensive micrometeorological measurements have been made over and within a Scots pine canopy. The structure of the canopy and its surface are described by measurements made on individual trees and by constructing a two-dimensional power spectrum of canopy surface height. This latter technique reveals important structural features that are not apparent when measurements on individual trees are considered alone. A comparison is made between the two-dimensional spectrum of this surface and that of surfaces with different values of k8 SUPER - SUPER 1 , and the relationship between surface structure and wind flow pattern is discussed.
DESCRIPTORS: Forest micrometeorology; Forest winds

27050365 ID NO.- MGA27050365
Particulate dispersion from sources within a forest.
Raynor, Gilbert S.; Hayes, Janet V.; Ogden, Eugene C.
Brookhaven Natl. Lab., Upton, N.Y.; N.Y. State Museum & Sci. Serv., Albany, N.Y.
Boundary Layer Meteorology, Dordrecht, Holland, 9(3): 257-277, Nov. 1975. Refs. DLC
Country of Publication: NL
Particulate dispersion from sources within a 10-13-m tall pine forest was studied experimentally at Brookhaven National Laboratory using stained ragweed pollen and other tracers ranging from 14 to 58 MU m in size. Forty-seven continuous point source releases, lasting from 22 to 55 min, were made at heights from 1.75 to 14.0 m from locations having a long fetch through the forest. In most experiments, differently colored ragweed pollen were emitted simultaneously from three locations. In other tests, several particle types were released from a single point. The sampling network consisted of 119 rotoslide samplers at heights from 0.5 to 21.0 m at 57 positions within and at the edge of the forest. Deposition to the ground was sampled by greased microscope slides at each position. Meteorological measurements were taken in and near the forest. Data were classified by particle characteristics, source height, and meteorological parameters. Concentration patterns were illustrated on scale diagrams of the sampling grid. Changes in centerline and crosswind integrated concentrations, plume width and height, mass flux, deposition, and deposition velocity were studied as a function of distance, particle size, and wind speed. Results were compared to those obtained from similar releases over open terrain. In the forest, vertical predominates over lateral dispersion, and considerable interchange occurs through the canopy. Flow is channelled somewhat by vegetation density differences, but is generally in the direction of the mean wind above the forest. No systematic turning of the wind with height was observed. Most particles are lost to the foliage rather than to the ground, and large particles are lost more rapidly than smaller ones. Rate of change in mass flux is similar to that over open terrain and is greater with light than with stronger wind speeds.

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DESCRIPTORS: Particle dispersion; Diffusion in forests

27030548 ID NO.- MGA27030548
Extraction of information on inorganic water quality.
Lane, William L.
Colorado. State Univ., Ft. Collins, Hydrology Papers, No. 73, July 1975. 76 p. Refs., figs., tables. DAS (A GB 705 C5)
Country of Publication: US
The potential for obtaining information concerning certain water quality variables on a stream by considering the relationships that exist between quality and quantity variables is examined. More precisely, the study is concerned with the relationship that exists between discharge and inorganic water quality in natural streams. Inorganic water quality is taken to refer to the concentrations of inorganic constituents found dissolved in the stream water. Natural streams are defined as those streams that are free of man's influence, although some compromise of this definition is necessary in actual application. The relationship studied is the negative correlation between inorganic water quality and discharge, which is found in virtually all streams. Study is limited to thirteen inorganic constituents: silica (SiO SUB 2), iron (Fe), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), bicarbonate (HCO SUB 3), sulfate (SO SUB 4), chloride (ClO), fluoride (F), nitrate (NO SUB 3), boron (B), and pH (minus the logarithm of the hydrogen ion activity). In addition, conductivity is taken as an indicator of the total inorganic dissolved solids concentration. Applications are made by using data from five streams: the Henry's Fork River at Linwood, Utah; the New Fork River near Big Piney, WY.; the Pecos River near Puerto de Luna, N.M.; the Saline River near Russell, KS.; and the Wind River at Riverton, WY. The same approach is used with data from each of the five streams, and similar results are noted. The approach consists of three basic parts: to develop the relationship between conductivity and discharge; to relate the constituent proportions to discharge; and to develop a relationship between the constituent concentrations and the conductivity. By using these three parts together, constituent concentrations are predicted from the stream discharge alone. The relationship between constituent concentrations and conductivity is based on chemical theory and is applicable to any stream sample. The other relationships have parameters that must be determined for each individual stream. The procedures and mathematical models presented in this study show promise of being generally applicable to all natural streams. In addition to extracting water quality information from discharge data, there are three areas of application which are also significant. First, the methodology shows promise of improving the understanding of water quality behavior and its relationship to discharge. Second, the development of relationships of this type permits a basis for meaningful judgments to be made concerning trends or other changes in the quality of a stream. Third, the relationships developed permit the possibility of analyzing and improving water quality sampling.
DESCRIPTORS: Water quality variables; River water composition; River water mineralization-river discharge relationships; United States

27030346 ID NO.- MGA27030346
Air movement in a forest clearing as indicated by smoke drift.
Bergen, J. D.
Rocky Mountain Forest & Range Experiment Station, U.S.D.A. ForestServ., Ft. Collins, CO.
Agricultural Meteorology, Amsterdam, 15(2): 165-179, Oct. 1975. Refs. DAS, DLC (600.A34)
Country of Publication: NL
Cinematic observations were made of the behavior of multiple smoke plumes in an isolated clearing cut in an even-aged stand of lodgepole pine. The clearing was 10 m by 80 m, and the average tree height was 10 m. Measurements were made against a tower grid, with simultaneous recording of the wind speed and direction above the canopy. Observations are discussed for times when the latter was within 30 deg of being perpendicular to the long axis of the clearing. Horizontal velocities for some portions of the clearing were estimated from the frame-to-frame displacement of plume irregularities. Vertical velocities were computed by continuity. The results indicate a continuous alternation between separated and unseparated flow, with the frequency of alternation in fair agreement with the eddy shedding frequency of the lee canopy region of the clearing, regarded as flatplate in uniform flow. The flow sequence includes a central vortex that closely resembles in form that found in square notches, but with higher angular velocities relative to the upwind friction velocity. This vortex appears to dominate the distribution and direction of the maximum speeds and surface shear stress in the clearing.
DESCRIPTORS: Airflow in forests; Forest clearings

27020347 ID NO.- MGA27020347
Evaporation from land areas.
Denmead, O. T.
Div. of Environ. Mechanics, CSIRO, Canberra
In: Australia. National Commission for United Nations Educational, Scientific, and Cultural Organization. Progress in Australian hydrology, 1965-1974. Canberra, Australian Gov. Pub. Service, 1974, p. 6-9. Refs. DAS (A GB 821 A8)
Country of Publication: AS
During the past decade, Australia has made significant contributions to evaporation research in three areas essential to meet problems of high evaporation potential and low average precipitation, characteristic of the country's climate: 1) methodology of evaporation measurement; 2) study of evaporation in two-dimensional situations; and 3) evaporation from soils and plants. Methodological progress includes development of improved eddy-correlation techniques for measuring evaporation rates, using the evapotron, the fluxatron, and a fast-response, IR hygrometer. Other new

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instruments measure the energy available for evaporation; and a recent development, the EPER, provides a continuous automatic recording of evaporation. Improved lysimeter design offers direct measurements of surface evaporation in agricultural areas. General formulas have been developed to calculate evaporation rates from standard meteorological observations-vertical gradients of wind speed, temperature, and humidity. In two-dimensional evaporation studies, progress has been made in understanding modifications of the global microclimate in certain special field situations, such as irrigation areas in dry land, limited size reservoirs, and surface vegetation and soil moisture changes. Other research includes development of a promising local advection theory and work on evolutionary aspects of energy transfer, the latter permitting estimates of actual evaporation rates from large land tracts on a routine climatological basis. Australian scientists have also intensified research in the physics of water retention, movement, and loss in the soil-plant continum. The major types of evaporation studied include that from a) soil; b) leaves; and c) crop canopies. Evaporation and water balance studies for different plant types are applicable especially to catchment by hydrology, where pine forest evaporation is found to exceed greatly that from grasslands in similar macroclimates.
DESCRIPTORS: Evaporation from land surfaces; Evaporation from plants; Australia

26090301 ID NO.- MGA26090301
Wind speeds within the trunk space of a pine forest
Oliver, H. R.
Div. of Atmos. Phys., CSIRO, Victoria, Australia
Royal Meteorological Society, Bracknell, Eng., Quarterly Journal, 101(427):167-172, Jan. 1975
Country of Publication: UK
Document Type: o
DESCRIPTORS: Wind profiles in forests
UCD NOT: 551.554:551.588.6

25080375 ID NO.- MGA25080375
Snow accumulation and snowmelt as influenced by a small clearing in a lodgepole pine forest.
Gary, Howard L.
U.S. Forest Serv., Ft. Collins, CO.
Water Resources Research, Wash., D.C. 10(2):348-353, April 1974.
Country of Publication: US
Document Type: o
DESCRIPTORS: Forest influences on snow accumulation; Forest influences on snowmelt
UCD NOT: 551.577.52:551.578.46:551.579.2:556.124

24100547 ID NO.- MGA24100547
Geomorphology and multiple glaciation in the area of Banff, Alberta.
Rutter, Nathaniel W.
Canada. Geological Survey, Ottawa, Bulletin 206, 1972. 54 p.
Country of Publication: CA
Document Type: o
Glacial deposits, consisting mainly of till and glaciofluvial deposits, indicate three or possibly four, major Wisconsin ice advances. Individual sections contain only limited parts of the total stratigraphic section, tills to two of the respective advances are not lithologically distinctive, and interstadial or interglacial deposits are lacking. Therefore, the stratigraphic succession upon which the glacial chronology was based is constructed from many incomplete sections, with considerable reliance on the geomorphology and areal relationships of the deposits. What is probably the earliest recorded glacial activity in the Banff area has been inferred from outwash underlying till deposited by the Bow Valley advance, although it is possible that this outwash may be associated with the overlying till. Widespread till deposits and breaks in slope at high elevations are the main evidence for the second, or Bow Valley advance, in which the ice extended well out into the foothills. Ice-contact fluvial deposits, believed to have been originally kame moraines, indicate at least two intervals of glacier equilibrium during deglaciation. The Canmore advance extended from the vicinity of Banff probably out to the foothills. This event is recorded by breaks in slope and by discontinuous patches of till over outwash deposited during the retreat of the Bow Valley ice. The fourth advance, the Eisenhower Junction advance, extended roughly as far as Eisenhower Junction. Evidence includes well-preserved ground and lateral moraines, breaks in slope, fresh cirques, and a terminal moraine. That a minor readvance followed is shown by till over ice-contract fluvial deposits laid down during the wastage of the Eisenhower Junction ice. A radiocarbon date of 9330 PLUS OR MINUS SOLID DELTA 170 yr B.P. (GSC-332), obtained in a nearby area, is correlated with the time of the Eisenhower Junction retreat. Three stades of the Pinedale glaciation (late Wisconsin) in the northwestern U. S. are temtatively correlated with the Bow Valley advance, the Canmore advance, and the Eisenhower Junction advance. The Altithermal interval is suggested by wind-blown material, containing a volcanic ash layer correlated with Mazama ash, overlying glacial deposits.
DESCRIPTORS: Glacial deposits; Glacial morphology; Wisconsin period ice cover; Banff, Alberta, Canada
UCD NOT: 551.32:551.583.3

24090182 ID NO.- MGA24090182
Estimated and measured roughness parameters for a pine forest.
Leonard, R. E.; Federer, C. A.
Northeastern Forest Experiment Station, U.S. Forest Serv.,
(cont. next page)

Durham, N.H.;
Journal of Applied Meteorology, Boston, 12(2):302-307, March 1973.
Country of Publication: US
Document Type: o
A topographic map of the upper surface of the canopy of a red pine(Pinus resinosa) plantation was drawn from 275 canopy heights measured on a grid of 0.9 MULTIPLIED BY 1.5 m. The distribution of heights was approximately normal, with a mean of 11.6 m and a standard deviation of 1.6 m; this is an improved method of designating stand height. The roughness parameter (z SUB o) and the zero-plane displacement (d) of the stand were estimated from the canopy map data by using both Kung's logarithmic formula and Lettau's equation for obstacle size and shape. These values were compared with measured z SUB o and d from wind and temperature profiles in near-neutral conditions. Lettau's formula, assuming the obstacles were uniform square-packed paraboloids, gave z SUB o = 138 cm and d = 10.6 m. Kung's formula gave z SUB O = 75 cm and d = 9.7 m. Measured profiles gave a median z SUB O = 100 cm after d was fixed at its median value of 9.6 m.
DESCRIPTORS: Roughness parameters; Forest effects on airflow
UCD NOT: 551.511.32:551.588.6

24080192 ID NO.- MGA24080192
Energy budgets in pine forest.
Stewart, J. B.; Thom, A. S.
Inst. of Hydrol., Wallingford, Eng.; Dept. of Met., Univ. of Edinburgh
Royal Meteorological Society, Bracknell, Eng., Quarterly Journal, 99(419): 154-170, Jan. 1973.
Country of Publication: UK
Document Type: o
Hourly, energy budgets measured in Thetford Forest, Norfolk, are analyzed for seven fine days in May-Sept. Values found for the Bowen ratio BETA , ranging from near 1. to 4 or more, are used to show that the bulk physiological resistance, GAMMA SUB S T, of the forest exhibits a consistent diurnal trend from near 1.2 s cm SUPER - SUPER 1 in the forenoon (once the trees are dry) to as much as 4 s cm SUPER - SUPER 1 by late afternoon consistent with independent biological measurements (Robins, personal communication). In contrast, the forest's bulk aerodynamic resistance, GAMMA , generally lies between 0.05-0.10 s cm SUPER - SUPER 1 . The ratio GAMMA SUB S T/ GAMMA alone, of order 20:1, implies that transpiration from the forest must occur at rates much less dependent, primarily, upon net radiation, R SUB n , than upon ambient vapor pressure deficit (v.p.d.), provided that the latter is not too small, i.e., SECTOR LEFT SOLID DELTA 1 mb per 100 W m SUPER - SUPER 2 of R SUB n . Also, the evaporation of intercepted rainfall from the trees must occur at about five times the corresponding transpiration rate under the same meteorological conditions. In addition, since lighter winds during fine weather tend to favor larger v.p.d's, the observed decrease in transpiration rate with increasing wind speed is much larger than that expected with a 1°C change in air temperature per hour, within the canopy, is 18 W m SUPER - SUPER 2 , which is not always negligible, as it is for short vegetation. Values derived for the dimensionless excess resistance parameter, B SUPER - SUPER 1 , although remarkaBly small (2 to 3 for u * APPROX. 0.75 m s SUPER - SUPER 1) are commensurate with other bulk aerodynamic resistances in the system. Accordingly, the easily-derived surface resistance parameter, GAMMA SUB S , (Monteith 1965, Thom 1972) provides an estimate of GAMMA SUB S SUB T or the forest within 10% for all BETA > 0.
DESCRIPTORS: Energy balance of forests; Thetford, England
UCD NOT: 551.511:551.584.41

24060299 ID NO.- MGA24060299
Mean wind-direction shear through a forest canopy.
Smith, F. B.; Carson, D. J.; Oliver, H. R.
Met. Off., Boundary Layer Res. Branch, Bracknell, Eng.; Inst. of Hydrol., Wallingford, Eng.
Boundary-Layer Meteorology, Dordrecht, Holland, 3(2):178-190, Dec. 1972.
Country of Publication: NL
Document Type: o
The equations of motion applying to the wind field in a forest canopy are simplified to a balance between the shearing stress gradient and either the form-drag of the leaves in the upper dense canopy, or the overall horizontal pressure gradient in the more open space beneath. The equations imply that, in descending through the forest, the stress and wind vectors turn through an angle that depends upon the forest characteristics and upon the stability and speed of the airflow above the forest. The turning is roughly confirmed by an overall average measured on a flat site near Thetford, Norfolk, covered by an extensive uniform pine forest.
DESCRIPTORS: Forest winds; Airflow in forests; Wind shear; Thetford, England
UCD NOT: 551.554:551.584.41

24040442 ID NO.- MGA24040442
Local climate as a factor forming hindrance of tree growth (preliminary report).
Yoshino, M. M. (ed.)
Hosei Univ., Tokyo, Dept. of Geograhy, Climatological Notes, No. 5, 1970. 65 p.
Language: mg
Country of Publication: JA
Document Type: o
Results are presented of the preliminary studies on local hindrance of tree growth and its relation to climatic factors. A bibliography was compiled on atmospheric pollution and damage to trees in urban areas in Japan and other countries. The distributions of damages of road-side and park trees by SO SUB 2 and insoluble substances in the urban atmosphere in Tokyo, Yokohama, and China, are delineated. The authors
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investigated the local conditions of hindrance to tree growth in the Irako Cape region, Aichi Prefecture, and found that less salt adhered to leaves of black pine (Pinus thunbergii), at the points 20-30 m into the forest. Large variations in the amount of salt adhering to leaves between sea-side and inland-side were found, even at points 300 m from the seashore. Observations were made in the coastal region in Ooiso, Kanagawa Prefecture, to investigate salty-wind damage to a citrus orchard with wind breaks. The Ginkgo trees (Ginkgo biloba), deformed by southerly wnds along the Sagami River, were observed as far as 40 km inland from the Pacific coast and their distribution in relation to the local wind conditions was analyzed. On Noto-jima Island on the Japan Sea coast it was pointed out, concerning the plant distribution, that the northern elements are found in the stronger wind region and the southerly elements, in the relatively weaker wind region. On the mountain slopes facing SW, S, and SE in the subalpine region in central Japan, the forests, at times, show striped patterns, with needle trees (Abies veitchii, A. mariesii) standing dead. These patterns were investigated on Mt. Yatsugatake and on other mountains and it was found that thery develop on slopes with thin soil layers and on large boulders, under the influence of prevailing southerly winds. These topographical conditions are confirmed from the viewpoint of geomorphology. Distributions of Podsol profile and coldness expressed by degree day of freezing (accumulated temperature below 0°C) were studied as indicators of local climatic conditions in thesubalpine regions, especially in central and northern Japan. Damagaes to Cryptomeria japonica and Chamaecyparis obtusa during the winter monsoon in Gumma Prefecture were studied statistically and it was found that the maximum frequency of damage occurs at 550-650 m above sea level with higher frequency seen in slopes facing N, NE, S, and SE. This is thought to occur because of the cold wind with low temperature on the slopes facing N and NE, and because of dry conditions on the slopes facing S and SE, which are leeward of the winter monsoon.
DESCRIPTORS: Atmospheric pollution damages to trees; Wind effects on trees; Climate and tree growth; Forest ecology; Japan
UCD NOT: 551.586:551.510.42:551.556.5:634.42

24020425 ID NO.- MGA24020425
Developmental and environmental history of the Dismal Swamp.
Whitehead, Donald R.
Dept. of Botany, IN. Univ., Bloomington
Ecological Monographs, Durham, N.C. 42(3):301-318, Summer 1972.
Country of Publication: US
Document Type: o
Pollen analysis of several cores from the Dismal Swamp in southeastern Virginia indicate that the swamp is a relatively young feature, having begun to develop along drainage lows as recently as the late-glacial. Formation of extensive fresh-water marshes along streams appears to have been brought about by general water-table changes controlled by the post-glacial rise of sea level. As the sea continued to rise, marsh development proceeded inland and fine-grained organic sediments began to accumulate. By 6000 yr B.P., approximately 50% of Dismal Swamp area had been mantled by fine-grained peat deposits. From 6000 to 3500 B.P., peat accumulation continued, but at an appreciably lower rate. This corresponds both to the hypsithermal interval and to a distinct slackening in the rate of sea-level rise. By 3500 B.P., peat had mantled virtually all of the interfluves and islands within the swamp. The pollen diagrams suggest a gradual change from boreal spruce-pine forests during the full-glacial to less boreal pine-spruce during the early late-glacial; to hardwood forests containing many species characteristic of the present northern hardwoods forests, during the latter portion of the late-glacial; to hardwood-dominated forests, containing species now found in southeastern VA., during the early postglacial. Although precise vegetational and environmental reconstructions are not possible, this general sequence suggests a unidirectional climatic amelioration from conditions comparable to those in northern New England, during the full-glacial, to a climate comparable to the present, by 6000 yr B.P. The climate may have been warmer and drier during the hypsithermal, but the observed changes could be a result of a slackening in the rate of sea-level rise. The cypress-gum forests that have characterized the Dismal Swamp for the past 3500 yr have been variable, both spatially and temporally. These variations reflect local differences in water table, peat depth, fires, wind throws, and a variety of human disturbances. The origin of Lake Drummond remains an enigma. It is a young feature of the swamp, apparently originating only 4000 yr ago. It is not the last vestige of an earlier open-water phase of the swamp.
DESCRIPTORS: Climatic changes; Swamp formation; Dismal Swamp, Virginia
UCD NOT: 551.583:551.481.2

23102996 ID NO.- MGA41040148
Dry deposition of particles to a pine plantation.
Lorenz, R.; Murphy, C. E., Jr.
E. I. du Pont de Nemours & Co., Savannah River Lab., Aiken, S.C.;
Boundary-Layer Meteorology, Dordrecht, Holland, 46(4): 355-366, March 1989. Refs. DLC
Country of Publication: NL
There has been some controversy concerning the rate of deposition of particles having diameters near 1.0 MU m to vegetated surfaces. In this size range, the processes of Brownian diffusion and inertial impaction are not effective, and deposition to smooth surfaces reaches a minimum. However, most measurements of deposition of micrometer-diameter particles to vegetated surfaces indicate a greater deposition than extrapolation of the results from less rough surfaces would suggest. In this study, the aerodynamic profile method was used to estimate deposition to a pine plantation. The
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DIALOG

deposition velocities were found to be sensitive to the displacement height and the form of the profile stability correction used in the calculations. An analysis of a limited set of Bowen ratio data, collected over the same forest, suggests that the data are reasonably described by using a displacement height of 7.9 m and the stability correction proposed by Raupach (1979). The average deposition velocities, measured over a 9-mo period, were 0.0043, 0.0078, and 0.0092 m/sec for the three diameter classes 0.5-1.0, 1.0-2.0, and 2.0-5.0 MU m. These deposition velocities are lower than the corresponding aerodynamic conductance for the same periods, indicating that the deposition rate is limited by surface phenomena. Average surface conductances calculated for the three size classes of particles were 0.0060, 0.0141, and 0.0276 m/sec, respectively. A multiple regression analysis showed high correlation between deposition velocity and wind speed. No other measured environmental factor or linear combination of factors was significantly correlated with deposition velocity.
DESCRIPTORS: Aerosol deposition over forests

21112905 ID NO.- MGA39050057
Eleven years of precipitation measurements above a small pole wood pine stand.
Jaeger, L.
Dept. of Met., Freiburg Univ., W. Germany
World Meteorological Organization, Geneva, Instruments and Observing Methods Report No. 25, April 1986, p. 101-103. Refs. (WMO/TD-No. 104). DAS (H QC 875.5 I58)
Country of Publication: SZ
Precipitation measurements were made during a long-term investigation concerning the energy balance of a pine forest. The 1974-1984 precipitation records were compared with the records of two German Weather Service stations, which record precipitation in the neighborhood of the forest. Then, the significance of the application of wind-shielded rain gages to estimate the precipitation above the rough forest surface was discussed. The discussion of comparative measurements that have been made with a normal, Hellmann-type rain gage and an Ombrometer HP is presented.
DESCRIPTORS: Rainfall measurement in forests; Shielded rain gages; Federal Republic of Germany

21083247 ID NO.- MGA39020399
Numerical analysis of pine forest evaporation and surface resistance.
Lindroth, Anders; Halldin, Sven
Dept. of Ecology and Environ. Res., Swedish Univ. of Agri. Sci.,Uppsala, Sweden; Div. of Hydrol., Uppsala Univ.
Agricultural and Forest Meteorology, Amsterdam, 38(1/3): 59-79, Oct. 1986. Refs., figs. DAS
Country of Publication: NL
Prediction of forest evaporation with the Penman equation that includes a surface resistance term is still hampered by ... well-established, steady-state, multilayer model was used to simulate evaporation of a pine forest in central Sweden, where previous measurements had shown a large difference between evaporation estimated by energy balance/Bowen ratio (EBBR) and water balance methods. Model input included profiles of turbulent diffusivity, boundary layer resistance, stomatal resistance, wind speed, net and global radiation, and needle area density. The surface resistance, r SUB s SUB s , as defined by the Penman equation, was always less than the bulk stomatal resistance, r SUB s SUB t . For a projected needle area index (LAI) of APPROX. 1.5, the r SUB s SUB s /r SUB s SUB t quotient was 0.5 but, for values of LAI > 4 or 5, it attained a constant value around 0.9. When ground evaporation was excluded, the canopy surface resistance, r SUB s SUB c , was very close to r SUB s SUB t (r SUB s SUB c /r SUB s SUB t EQUALS APPROX. 0.95) for all LAI. Bulk stomatal resistances based on point values of stomatal conductance implied r SUB s SUB s /r SUB s SUB t and r SUB s SUB c /r SUB s SUB t values largely differing from unity. The operational definition of average stomatal resistance was, therefore, an important point. Simulated evaporation for representative days of the discrepancy period gave support to EBBR measurements. It was suggested that different areal representativity might explain differences between the evaporation estimation methods. A sensitivity analysis showed that vapor pressure deficit and net radiation were equally important to determine forest evaporation, but net radiation influenced it indirectly through the surface resistance.
DESCRIPTORS: Evaporation from forests; Evaporation estimation

21033370 ID NO.- MGA36090522
Opere frangivento: Intervento sperimentale a protezione della S.S.638 del Passo Giau. [Wind-breaking operations: experimental efforts to protect Route 638 at Giau Pass.]
Balzaretti, Piermichele
Neve e Valanghe, Arabba, Italy, No. 1, June 1985, p. 19-28. Refs., figs.
Language: It
Country of Publication: IT
The Experimental Center on Avalanches and Hydrogeological Protection of the Arabba Region of Veneto investigated problems connected with the study of wind deflectors adapted to pine geomorphological and climatic conditions. The term wind deflectors means that category of structures which, when placed transversely to the wind flow, permits rectification of the snow accumulations transported by the wind. The study involves true deflectors and accelerators. The deflectors are formed by barriers 4-6 m high placed transversally to the slope and are designed to break or slow down the wind flow and to create, on the ice side, favorable conditions for deposition of the snow that is transported by the wind. The accelerators consist of transverse barriers to the wind flow formed by highly inclined elements which, in relation to the

direction of the wind source, assume a form of springboard or funnel. The purpose of these structures is to produce an acceleration of the wind flow by impeding the deposition of the snow in the proximity of the point where they are located. Three phases of the research are described: 1) the investigation of the materials of the two kinds of barriers; 2) the investigation of the position as a function of geomorphological conditions; and 3) the analyses and verification of the fundamental hypotheses. The discussion is illustrated by diagrams and photographs.
DESCRIPTORS: Snow drift control; Giau Pass, Alps, Europe

21010057 ID NO.- MGA21010057
Inaja Fire-1956, Pine Hills Fire-1967...similar, yet different.
Schroeder, Mark J.; Taylor, Bernadine B.
both, Forest Fire Lab., Riverside, Calif.
U. S. Forest Service. Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif., Forest Service Research Note PSW-183, 1968. 7 p, Figs., tables, ref.
DESCRIPTORS: Forest fire conditions; Wind effects on forest fires; Fire weather; Fire behavior studies; Inaja, California Pine Hills, California

20123211 ID NO.- MGA38060383
Pine forest microclimate simulation using different diffusivities.
Halldin, Sven; Lindroth, Anders
Div. of Hydrol., Uppsala Univ., Sweden; Dept. of Ecology and Environ. Res., Swedish Univ. of Agri. Sci.,Uppsala
Boundary-Layer Meteorology. Dordrecht, Holland, 35(1/2): 103-123, April 1986. Refs. DLC
Country of Publication: NL
Proper understanding of evaporation from a forest requires an understanding of its microclimate. A well-established, steady-state model was used to simulate microclimate and evaporation of a sparse pine forest in central Sweden. Model input included profiles of turbulent diffusivity, boundary layer resistance, stomatal resistance, wind speed, net and global radiation, and needle area density. Momentum balance, energy balance, and exponentially decreasing diffusivities were used to study the sensitivity of the evaporation rates and of the temperature and humidity profiles. Model output proved to be unreliable when measured temperature and humidity at the bottom of the stand were used instead of a measured ground heat flux as the lower boundary condition. Energy balance diffusivity was usually larger than momentum balance diffusivity at the canopy top, but decreased rapidly to a minimum at approximately the height where the momentum balance diffusivity had its maximum. Energy balance diffusivity commonly showed a secondary maximum below the height of the maximum needle area density. Profiles of Richardson number showed that thermal effects became important just below the canopy top. Bluff-body effects distinguished the energy balance from the momentum balance diffusivity, and both were subject to shelter effects. Total evaporation was not very sensitive to the choice of diffusivity when soil heat flux was given as the lower boundary condition.
DESCRIPTORS: Forest microclimates; Evaporation from forests

20023314 ID NO.- MGA37080466
Simulating interception loss using standard meteorological data.
Mulder, J. P. M.
Vakgroep Fysische Geog. en Bodemkunde, Geol. Inst., Rijksuniv.Groningen
In: Conference on Forest Environmental Measurements, Oak Ridge, TN., Oct. 23-28, 1983, Forest-atmosphere interaction: Proceedings, Dordrecht, D. Reidel Publ. Company, 1985. p. 177-196. Refs., figs., tables. DLC (QK938.F6F66)
Country of Publication: NL
A model was derived to calculate interception loss from a forest canopy on the basis of thrice daily observations of air temperature and relative humidity, daily means of wind run, daily totals of precipitation, and the number of rainy hours and of bright sunshine. The forest canopy was characterized by mean tree height, crown density, and water storage capacity. The model was calibrated and tested on four separate data sets obtained during 1964, 1966, 1980, and 1981 in the pine forest of the lysimeter station near Castricum, the Netherlands. Model sensitivity was demonstrated for roughness length, the above canopy wind correction factor, and relative humidity during rain. Simulated net precipitation explained at least 92% of the observed net precipitation, which indicates a good predictive model.
DESCRIPTORS: Water losses; Precipitation interception by forests

20013303 ID NO.- MGA37070465
Mass transfer in the snow cover of central Yakutia.
Are, A. L.
Permafrost Inst., Siberian Branch, Acad. of Sci., Yakutsk A.S.S.R.
. International Conference on Permafrost, 4th, Fairbanks, Alaska, July 17-22, 1983, Final Proceedings. Wash., D.C., National Academy Press, 1984. p. 204-207. Refs. DLC
Country of Publication: US
On the basis of 10-yr of experimental research, it has been established that the intensity of mass transfer in the snowpack is temperature-dependent and reaches its maximum at snow temperatures above -20°C. The mean rate of vapor diffusion in snow layers near the base of the pack varies between (2.0-2.5) MULTIPLIED BY 10 SUPER - SUPER 3 g/cm SUPER 2 /day. The norms were obtained for snow sublimation for all types of landscape in Central Yakutia, e.g., 12 mm on meadows; 5.5 mm in pine forest; 6.2 mm in larch forest; and 8.5 mm on lake ice. The value for mean daily sublimation of snow is determined on the basis of the air

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humidity deficit and the wind velocity. Ten-day sublimation totals were determined on the basis of the absorbed radiation.
DESCRIPTORS: Sublimation of snow; Water vapor diffusion through snow cover; Yakutsk, Asiatic R.S.F.S.R.