Penman's Equation

$$PET = \frac{A H_n + E_a \gamma}{A + \gamma}$$

PET = daily potential evapotranspiration in mm per day

A = slope of the saturation vapour pressure *vs* temperature c
mean air temperature, in mm of mercury per °C (Table 3

H_n = net radiation in mm of evaporable water per day

E_a = parameter including wind velocity and saturation deficit

γ = psychrometric constant = 0.49 mm of mercury/ °C

Penman's Equation

$$H_n = H_a(1-r)\left(a + b\frac{n}{N}\right) - \sigma T_a^4 (0.56 - 0.092\sqrt{e_a})\left(0.10 + 0.90\frac{n}{N}\right) \quad (3.14)$$

H_a = incident solar radiation outside the atmosphere on a horizontal surface, expressed in mm of evaporable water per day (it is a function of the latitude and period of the year as indicated in Table 3.4).

a = a constant depending upon the latitude ϕ and is given by $a = 0.29 \cos \phi$

b = a constant with an average value of 0.52

n = actual duration of bright sunshine in hours

N = maximum possible hours of bright sunshine (it is a function of latitude as indicated in Table 3.5)

r = reflection coefficient (albedo). Usual ranges of values of r are given

σ = Stefan-Boltzman constant $= 2.01 \times 10^{-9}$ mm/day

T_a = mean air temperature in degrees kelvin $= 273 + °C$

e_a = actual mean vapour pressure in the air in mm of mercury

Surface	range of r values
Close ground corps	0.15—0.25
Bare lands	0.05—0.45
Water surface	0.05
Snow	0.45—0.95

The parameter E_a is estimated as

$$E_a = 0.35\left(1 + \frac{u_2}{160}\right)(e_w - e_a)$$

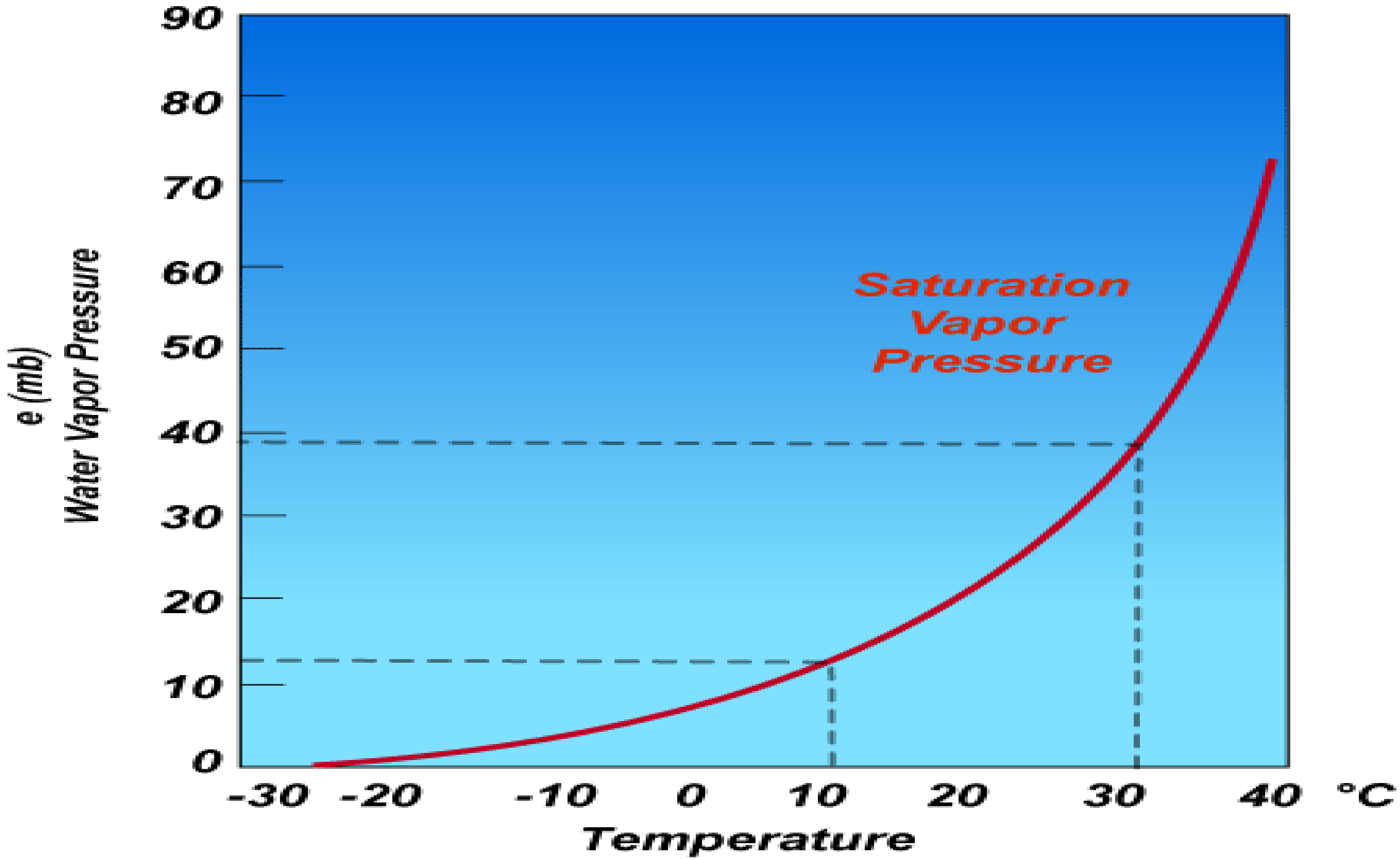
in which

u_2 = mean wind speed at 2 m above ground in km/day

e_w = saturation vapour pressure at mean air temperatur
(Table 3.3)

e_a = actual vapour pressure, defined earlier

Saturation Vapour Pressure Vs Temperature curve



FAO Penman-Monteith

$$ET_o = \frac{0.408\,\Delta\,(R_n - G) + \gamma \frac{900}{T+273} u_2\,(e_s - e_a)}{\Delta + \gamma(1 + 0.34\,u_2)}$$

ET_o	reference evapotranspiration [mm day^{-1}],
R_n	net radiation at the crop surface [MJ m^{-2} day^{-1}],
G	soil heat flux density [MJ m^{-2} day^{-1}],
T	mean daily air temperature at 2 m height [°C],
u_2	wind speed at 2 m height [m s^{-1}],
e_s	saturation vapour pressure [kPa],
e_a	actual vapour pressure [kPa],
e_s-e_a	saturation vapour pressure deficit [kPa],
Δ	slope vapour pressure curve [kPa °C^{-1}],
γ	psychrometric constant [kPa °C^{-1}].

Evapotranspiration of other crops can be related using crop factor

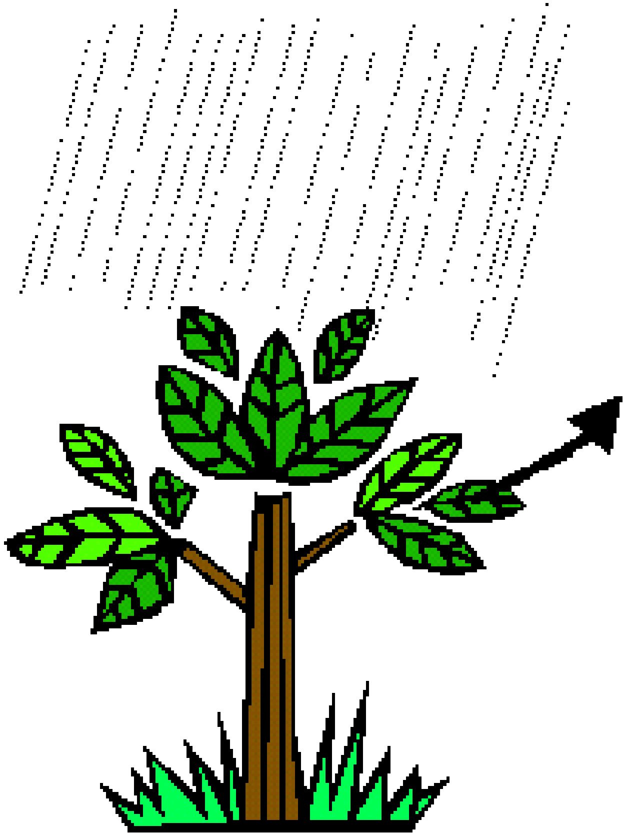
Separation of Evaporation from Evapotranspiration

$$E_P = PET.\exp\left(-b.LAI\right)$$

$$T_P = PET - E_P$$

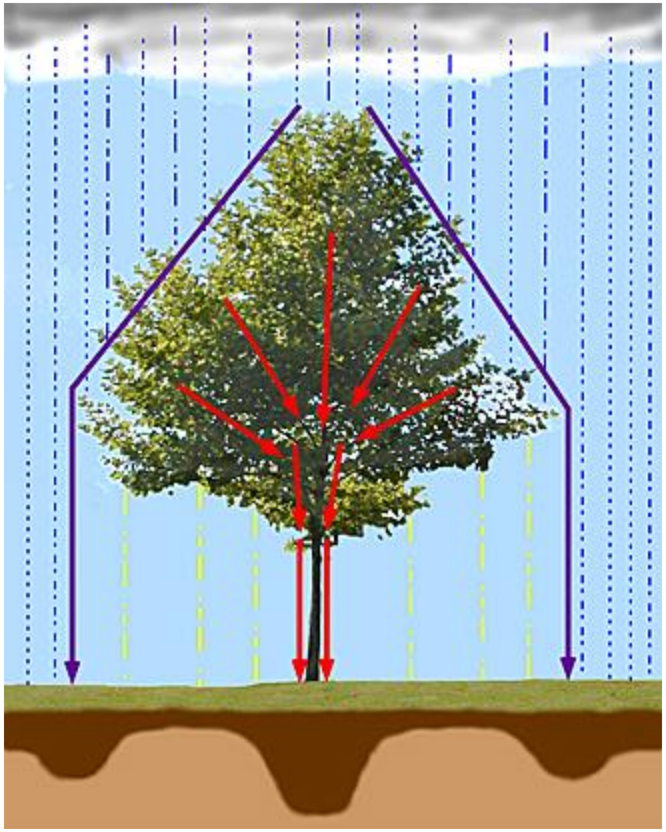
Interception Loss

- It is that portion of precipitation, which while falling, is intercepted by aerial potion of vegetation, buildings and other objects above the surface of earth and evaporates back to the atmosphere



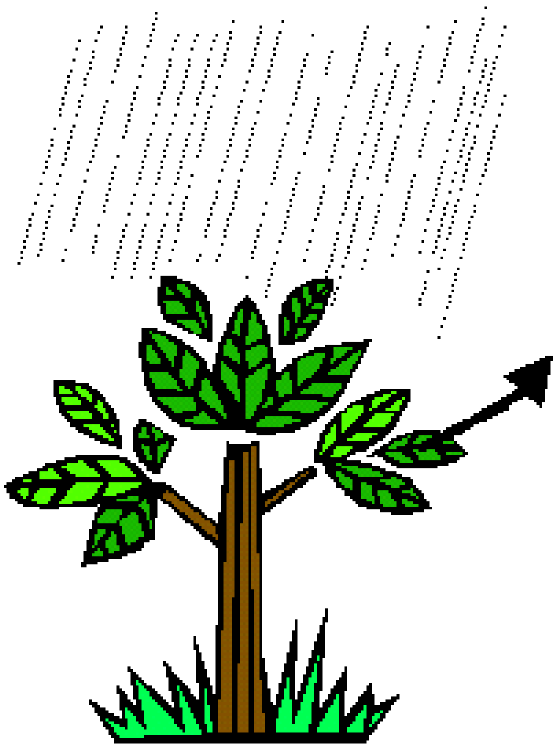
Not Interception Loss

- Stem flow red arrows
- Canopy drip purple arrows
- *Through fall* yellow dashed lines

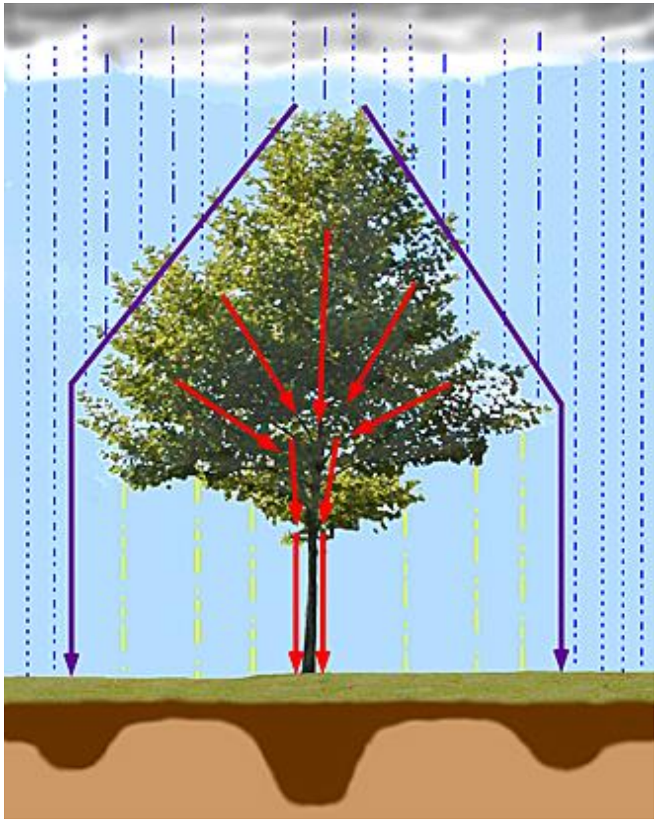


Interception loss

Light Rain



Heavy rain



Factors affecting interception

- **Meteorological factors**
  - precipitation intensity
  - precipitation duration
  - wind speed
  - type of rainfall: rain versus snow
  - precipitation frequency
- **Vegetation characteristics**
  - growth form: trees, shrubs, grasses, forbs
  - plant density
  - plant structure: number, size, flexibility, strength and pattern of branches; texture, surface area and

Amount of water intercepted in a given area is difficult to measure.

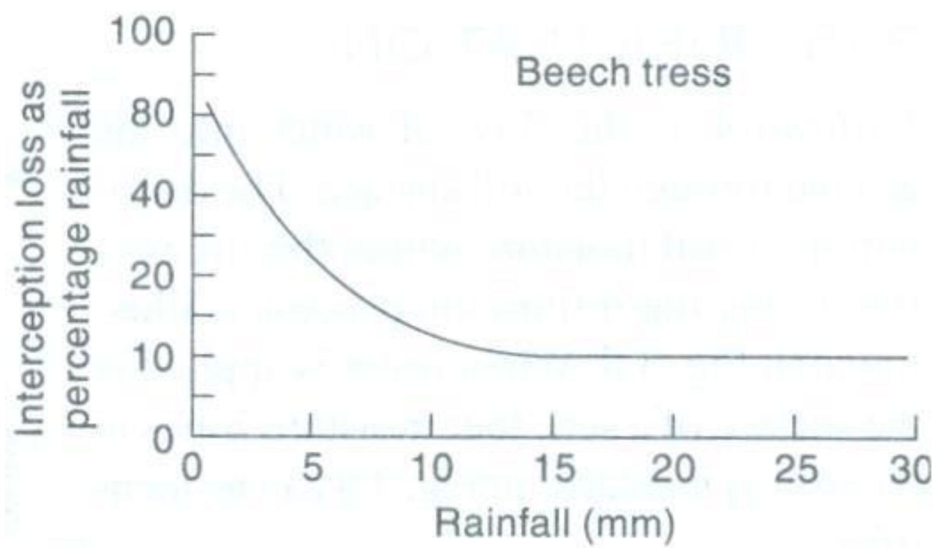
Depends on 1) Species composition of vegetation

2) its density, and also

3) Storm characteristics.

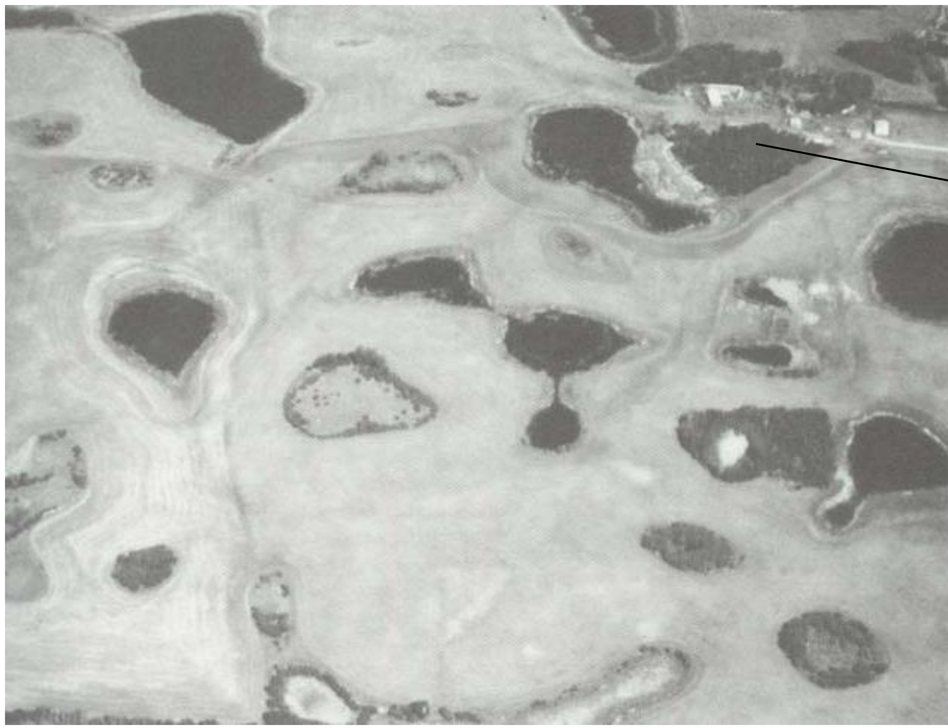
It is estimated that during a plant growing period the interception loss could be **10-20% of rainfall.**

If frequent rainfall occurs, the annual interception losses over forest regions could be high**, ≥ 25% of the annual precipitation**.



Typical Interception Loss Curve

Depression storage



The volume of water stored in depressions is called depression storage.

- **Depression storage**

Factors influencing depression storage :

i. **The type of the soil**
ii. **The condition of the surface reflecting the amount and nature of depression.**
iii. **The slope of the catchment**
iv. **The antecedent precipitation.**

Qualitatively found that antecedent precipitation has a very pronounced effect on decreasing the loss to runoff in a storm due to depression.

During intensive storm 0.5 cm depression storage in sandy soil,

0.4 cm in loam,

0.25 cm in clay.

Factors Affecting Depression Storage

- Soil characteristics
- Surface condition
- Land use pattern
- Topography
- Antecedent precipitation

Effective rain = Rainfall – Interception loss