Spectral Reflectance Curve

The graphical representation of the spectral response of an object over different wavelengths of the electromagnetic spectrum is termed as *spectral reflectance curve*. The reflectance characteristics of the surface features are represented using these curves.

These curves give an insight into the spectral characteristics of different objects, hence used in the selection of a particular wavelength band for remote sensing data acquisition.

The graph is drawn between various wavelengths (μm) of EM spectrum on *x-axis* & the amount of reflectance (%) recorded by the R.S. system on the *y-axis*.

Spectral reflectance curve exhibits the "peak-and-valley" configuration. High amount of reflectance of a wavelength from a particular feature may result in *peaks* in the graph & low reflectance results in a *dip* or *valley* in the curve. In other words, the peaks indicate strong reflection of incident energy and the valleys indicate predominant absorption of the energy in the corresponding wavelength bands.

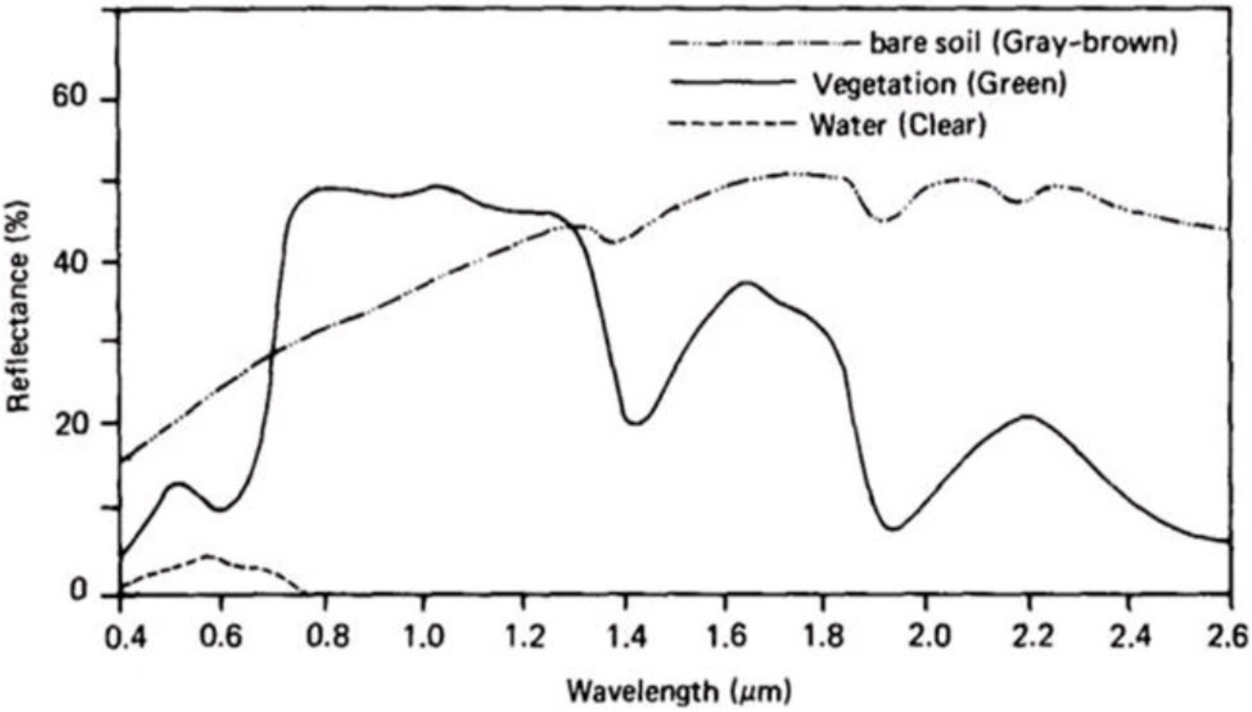


Figure: Spectral Reflectance Curve for vegetation, soil &water

NOTE: The peaks & dips in these curves are very specific, at definite wavelengths, so should be carefully & correctly drawn at exact wavelength (μm). For example, within visible region(0.4-0.7 μm), the curve for vegetation will have dips exactly at 0.45 μm & 0.67 μm.

1. Spectral Reflectance Curve for Vegetation

Spectral reflectance curve for healthy green vegetation exhibits the "peak-and-valley" configuration as illustrated in Fig.1. It can be studied in three categories viz. wavelength region (0.4-0.7μm), (0.7-1.3μm) & beyond 1.3μm.

In general, healthy vegetations are very good absorbers of electromagnetic energy in the visible region (0.4-0.7μm). The absorption greatly reduces and reflection increases in the red/infrared boundary near 0.7 μm. The reflectance is nearly constant from 0.7-1.3 μm and then decreases for the longer wavelengths.

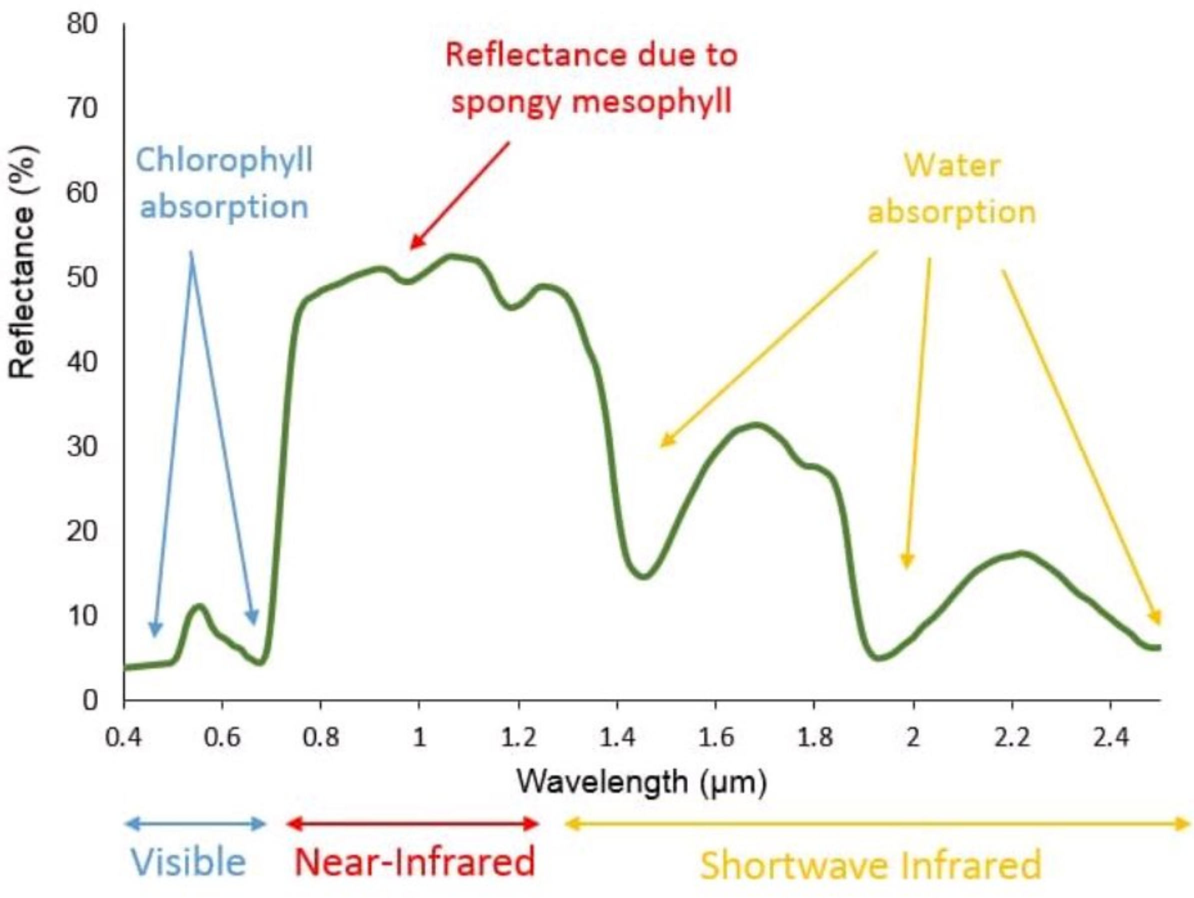


Fig.1. Typical Spectral Reflectance Curve for vegetation

Spectral response of vegetation depends on the structure of the plant leaves. Fig. 2 shows the cell structure of a green leaf and the interaction with the electromagnetic radiation (Gibson 2000).

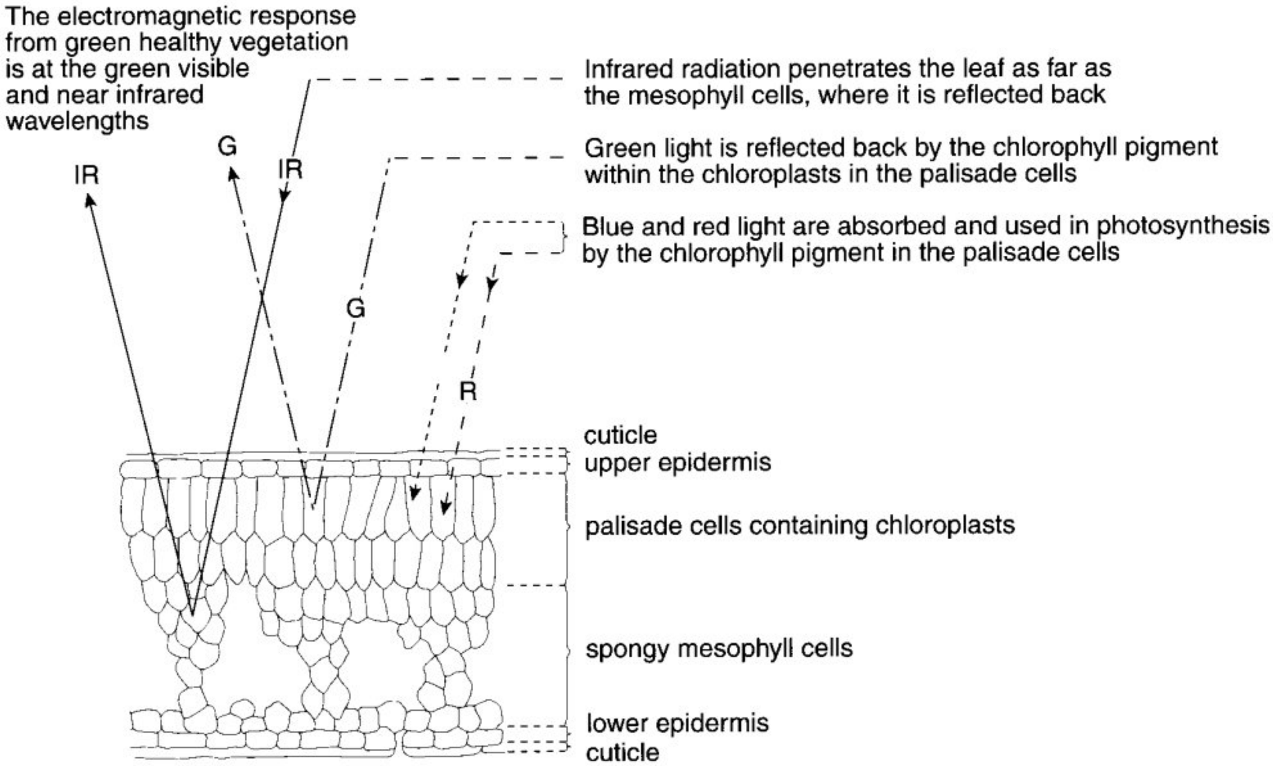


Fig.2. Cell structure of a green leaf and interactions with the electromagnetic radiation (Gibson, 2000)

The valleys in the ***visible region*** **(0.4 to 0.7 µm)** of the spectrum are due to the pigments in plant leaves. The palisade cells containing sacs of green pigment (chlorophyll) strongly absorb energy in the wavelength bands centered at 0.45 and 0.67 µm within visible region (corresponds to blue and red), as shown in Fig.3. On the other hand, reflection peaks for the green colour in the visible region, which makes our eyes perceive healthy vegetation as green in colour. However, only 10-15% of the incident energy is reflected in the green band.

In the ***near infrared (NIR) region*** **(0.7 to 1.3 µm)** of the spectrum, at 0.7 µm, the reflectance of healthy vegetation increases dramatically. In the range from 0.7 to 1.3 µm, a plant leaf reflects about 50 percent of the energy incident upon it. The infrared radiation penetrates the palisade cells and reaches the irregularly packed mesophyll cells which make up the body of the leaf. Mesophyll cells reflect almost 60% of the NIR radiation reaching this layer. Most of the remaining energy is transmitted, since absorption in this spectral region is minimal. Healthy vegetation therefore shows brighter response in the NIR region compared to the green region. As the leaf structure is highly variable between plant species, reflectance measurements in this (NIR) range often permit <u>discrimination between species</u>, even if they look same in visible range as seen in Fig. 3.

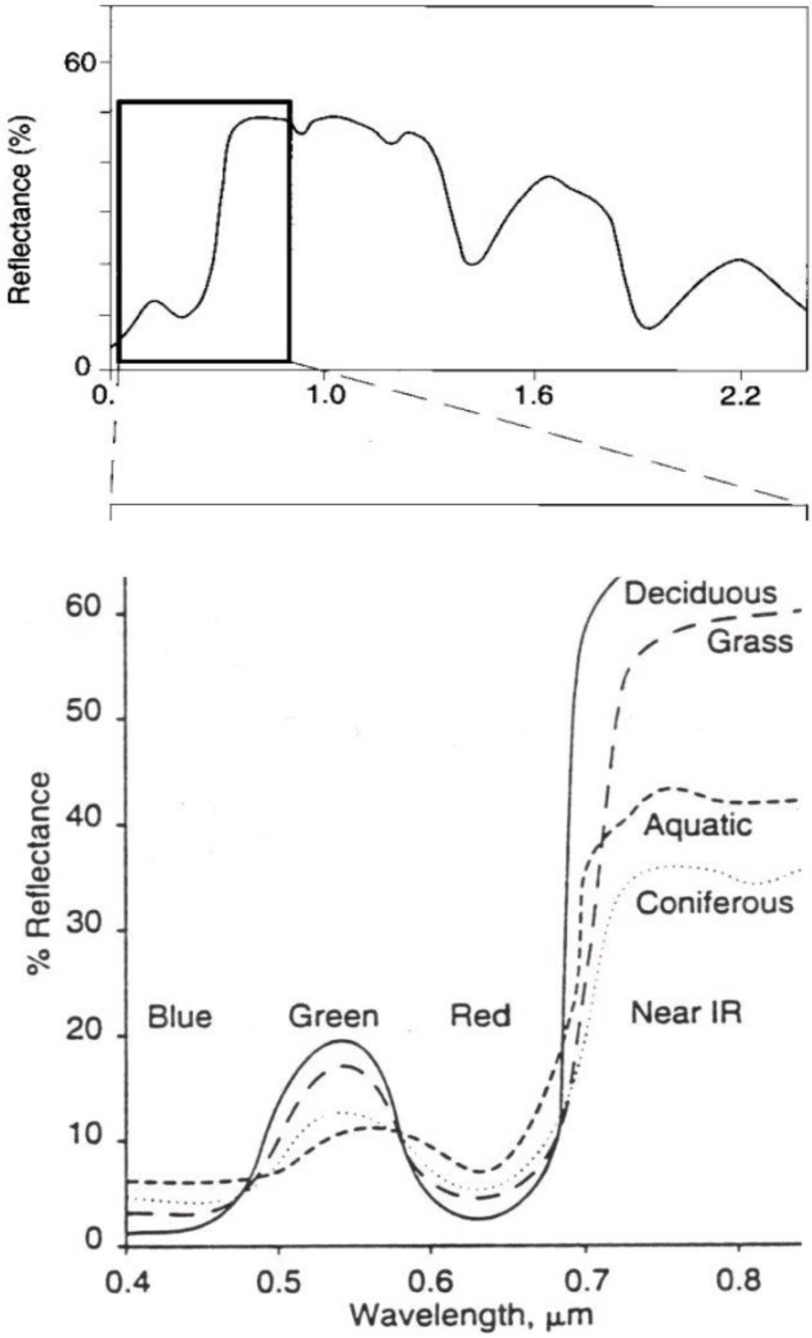


Fig.3. Spectral reflectance of healthy vegetation in the visible and NIR wavelength bands

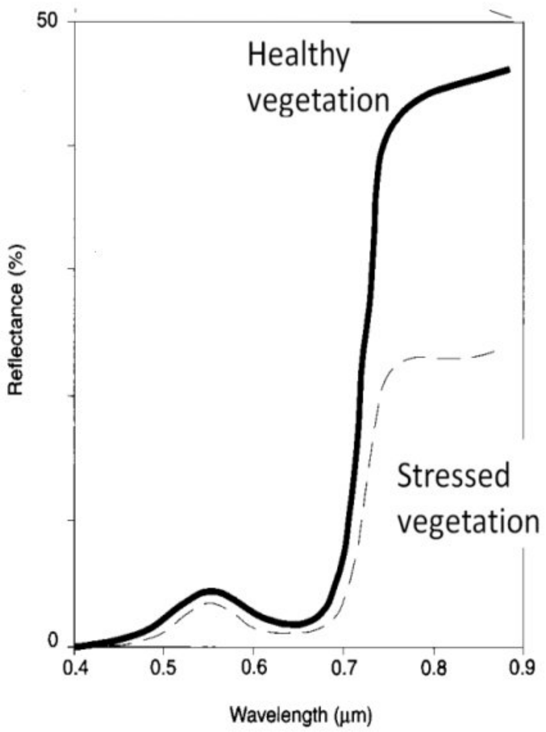
In the region *beyond 1.3 µm*, leaf reflectance is approximately inversely related to the total water present in a leaf as water absorbs the energy. This total water is a function of both the moisture content and the thickness of the leaf.

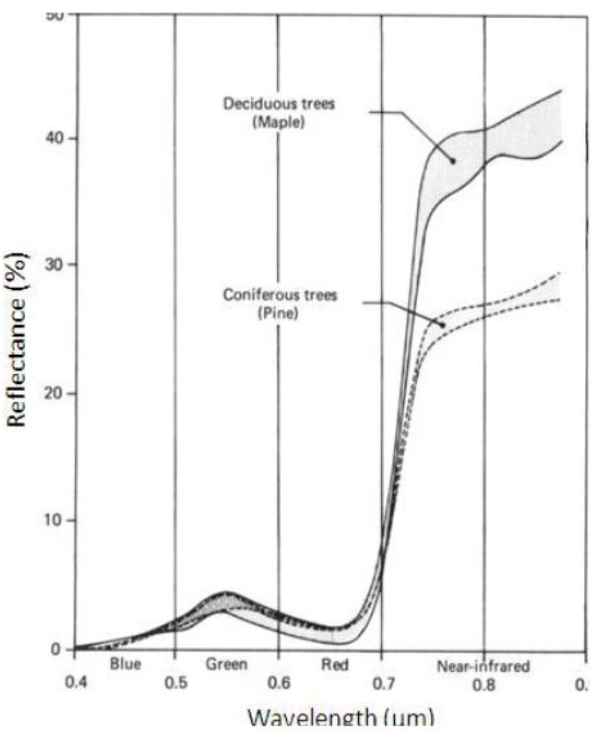
Dips in reflectance occur at **1.4**, **1.9**, and **2.7 µm** (Fig.1.) as water in the leaf strongly absorbs the energy at these wavelengths. So, wavelengths in these spectral regions are referred to as *water absorption bands*. Reflectance peaks occur at **1.6** and **2.2 µm** (Fig.1.), between the absorption bands.

Some important features & facts:

a) Vegetation canopies generally display a layered structure. Therefore, the energy transmitted by one layer is available for reflection or absorption by the layers below it (Fig. 4). Due to this multi-layer reflection, total infrared reflection from thicker canopies will be more compared to thin canopy cover. From the reflected NIR, the **density** of the vegetation canopy can thus be interpreted.

b) If a plant is subjected to some form of stress that interrupts its normal growth and productivity, it may decrease or cease chlorophyll production. The result is less absorption in the blue and red bands in the palisade. Hence, red and blue bands also get reflected along with the green band, giving yellow or brown colour to the stressed vegetation. Also in **stressed vegetation**, the NIR bands are no longer reflected by the mesophyll cells, instead they are absorbed by the stressed or dead cells causing dark tones in the image.





c) As the reflectance in the IR bands of the EMR spectrum varies with the leaf structure and the canopy density, measurements in the IR region can be used to discriminate the tree or vegetation species. For example, spectral reflectance of **deciduous and coniferous trees** may be similar in the green band. However, the coniferous trees show higher reflection in the NIR band, and can be easily differentiated (Fig.5). Similarly, for a densely grown agricultural area, the NIR signature will be more.