

## Fall Color Expression

by Dr. Kim D. Coder, Warnell School of Forestry & Natural Resources, University of Georgia

The desire of people to see the best tree colors nature has to offer means estimating a time of peak color expression. This estimation process is fraught with problems because predictions are only as good as weather forecasts, tree health, and good chance allows. Human eyesight and color recognition also play a strong role in judging the quality and quantity of landscape color. Additionally, it is not necessarily the single tree and its colored leaves we most appreciate. As annual flowers may be massed together to yield a spectacular color show, trees can be seen as massed across a landscape in fall. The large swathes of tree colors blanketing autumn landscapes can be fantastic.

### A Good Thing

Across a forested or tree-covered landscape, human color perceptions differ as much as tree colors. Some people enjoy and notice the early high contrast yellow stages of coloration. Others most appreciate the diversity of colors during the orange color peak. For other people, deep reds and purples of late Fall represent the best color presentations. Actually, the best colors are ones you can see and enjoy. Even people with limited color perception (color-blind) can enjoy the differences in texture and color contrasts developed in Fall. Any excuse for communing with trees and forests in search of autumn colors is a good thing.

### Color Conditions

Fall colors are generated when chlorophyll is destroyed and other pigments are revealed or manufactured. Any climatic, site, or tree feature that modifies pigments will impact Fall colors. Probably most important to strong color presentations are the weather patterns of the preceding Summer and Fall. In some trees (most notably with ring-porus wood architecture), even events early in the previous Spring can affect this year's Fall colors. The best conditions for Fall tree colors are: cool night temperatures with no freezes or frosts; warm, bright, unclouded sunny days; no drenching rains or wind storms; and, slight drought conditions in the last half of the growing season and on into the fall. Table 1.

As in all life-associated functions, a healthy tree is needed for best color expression. A simple summary of good color conditions would be cool (not freezing), sunny, and dry. Fall rain fronts, long overcast periods, and extended periods of high humidity diminish color presentation. So do strong wind storms that blow leaves from trees. Wet and humid growing seasons lead to many leaf infections, premature leaf abscission, and leaching of materials from leaves. Heavy fertilizer applications of nitrogen and phosphorus can mute color expression, maintain chlorophyll longer into the season until a killing frost, or initiate leaf abscission from pests colonizing and damaging late season leaves. Freezing temperature and hard frosts stop color formation dead.

### Color Patterns

Figures 2-6 are maps which help project color expression during Fall across the Eastern United States based upon historic weather measures. Figure 2 shows the month when the average sunshine hours decrease to

## Table 1: Process summary steps in developing leaf color from late Summer to late Fall.

Leaf color formation is a natural process in trees.

Short days & cool nights of Fall bring changes to trees.

Green colored light-capture systems decline.

Turning-off leaves lets green colors fade, revealing hidden colors.

Natural leaf senescence reveals old colors and makes new colors.

Best colors come with cool, dry, and bright sunny days.

Frosts, freezes, clouds, storms and rain hurt color expression.

Set of colors like oil-paints called carotenoids (reds, oranges, yellows).

Set of colors like watercolors called anthocyanins (reds, purples, blues).

Set of colors like earth-tones called tannins (tans, browns).

Many different combinations of colors produced. Figure 1.

Leaves sealed-off from tree and the environment knocks them off.

Fall colors are not a last gasp, but a first breath of next Spring.

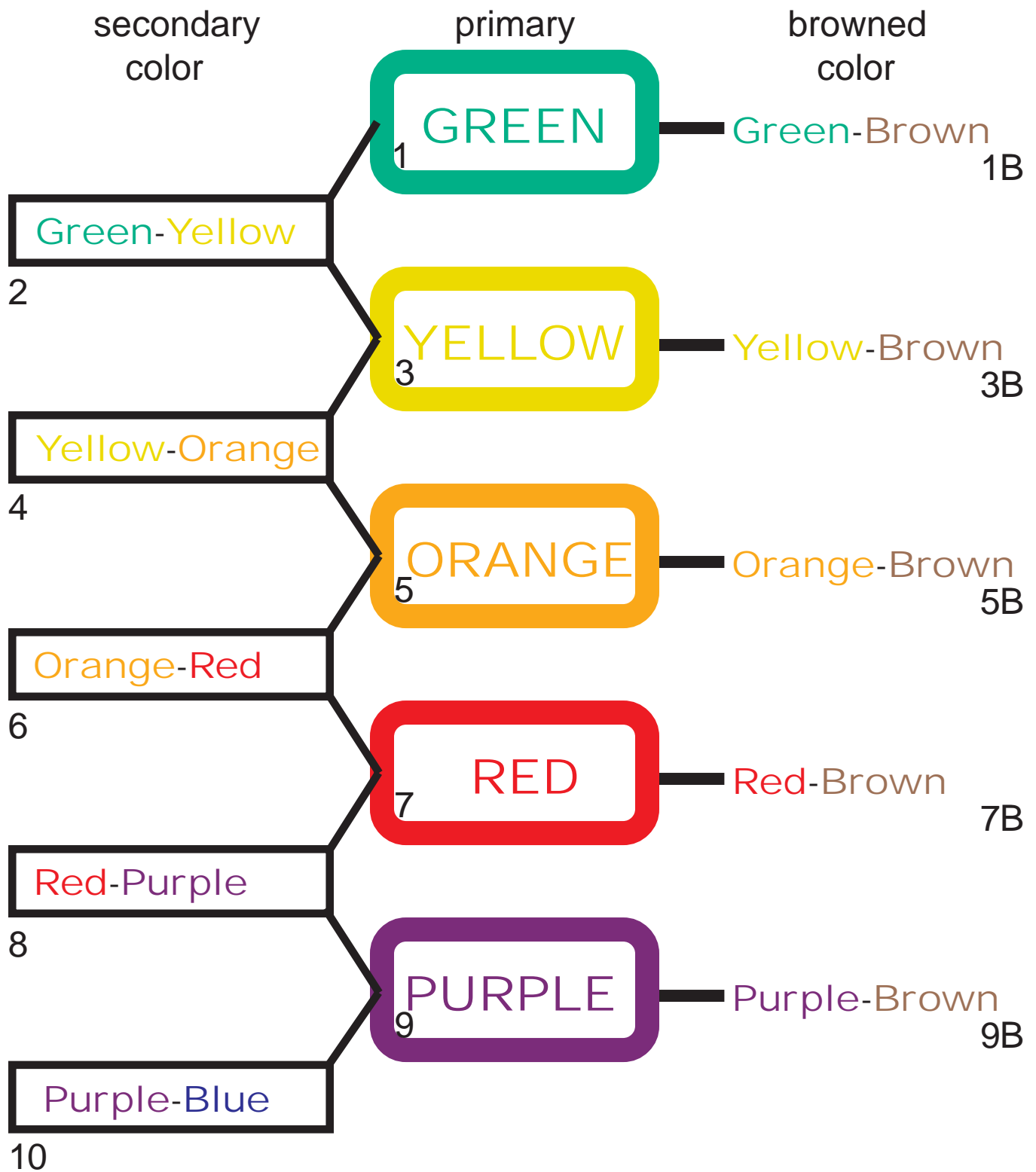


Figure 1: The 15 primary, secondary, and browned autumn tree colors with associated Coder Leaf Color Code values. Each color is modified by

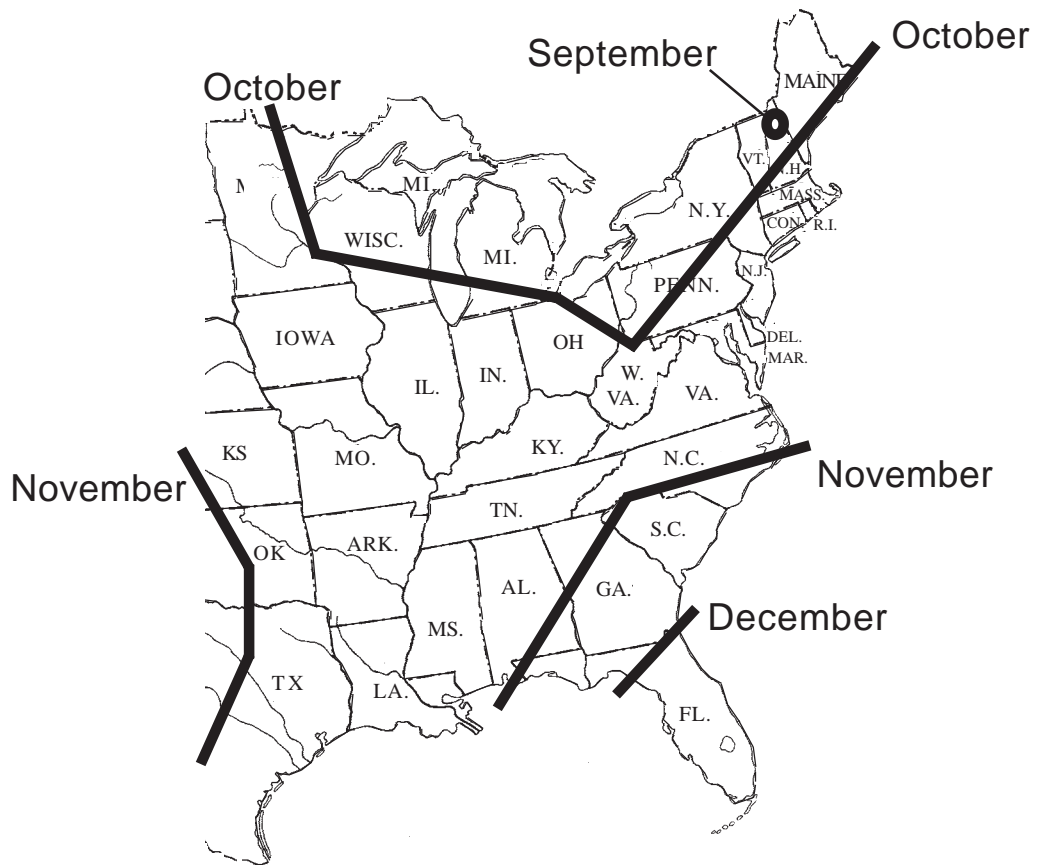


Figure 2: Average monthly progression of 180 sunshine hours South across the Eastern United States.

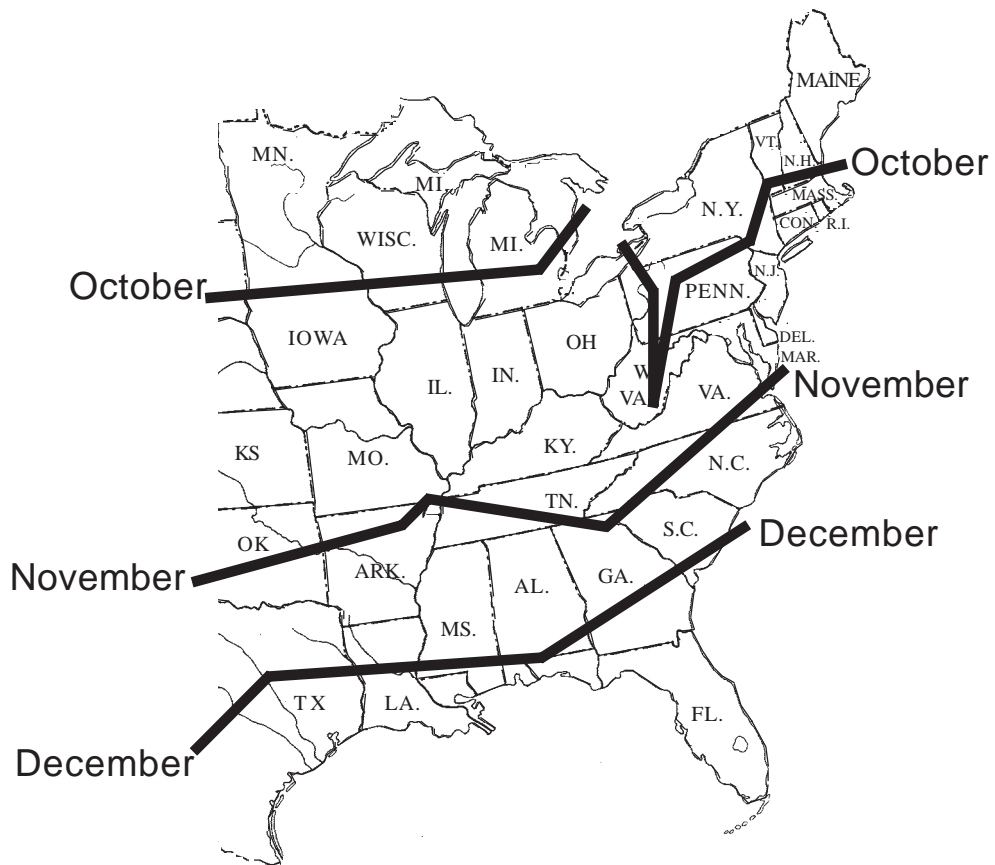


Figure 3: Average daily temperature of 50°F progression South across the Eastern United States in autumn.

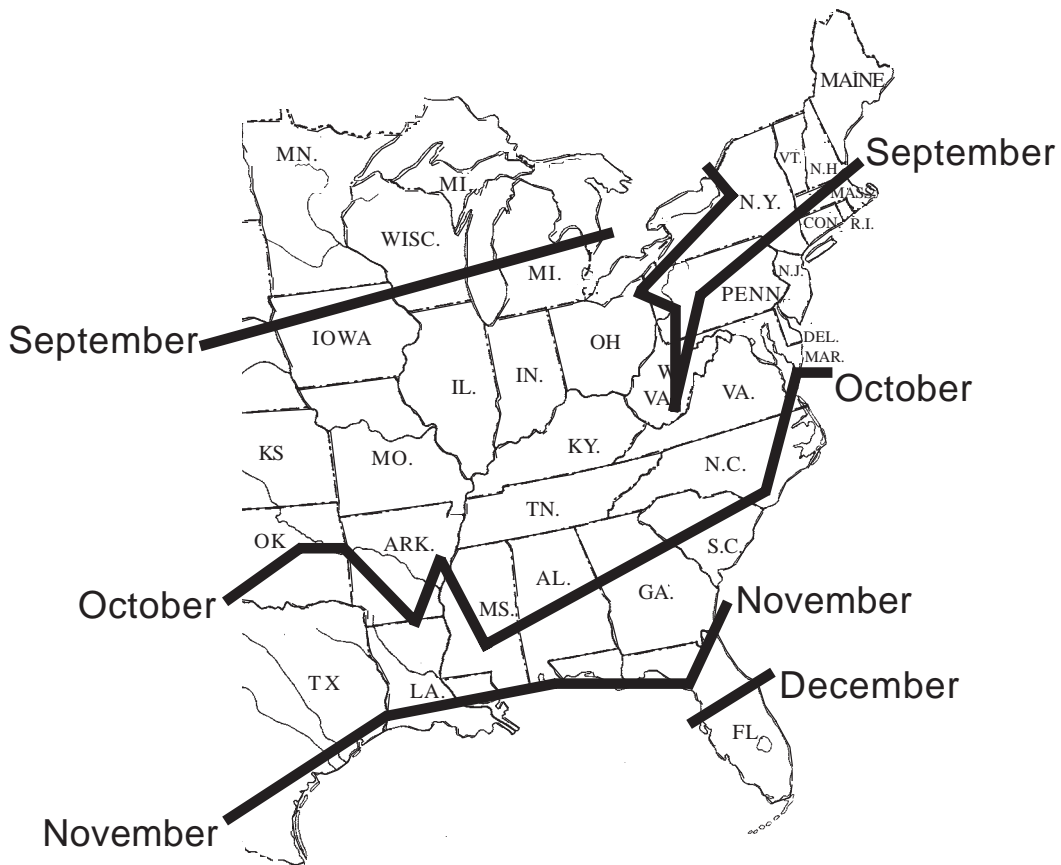


Figure 4: Average daily minimum temperature of 50°F progression South across the Eastern United States in autumn.

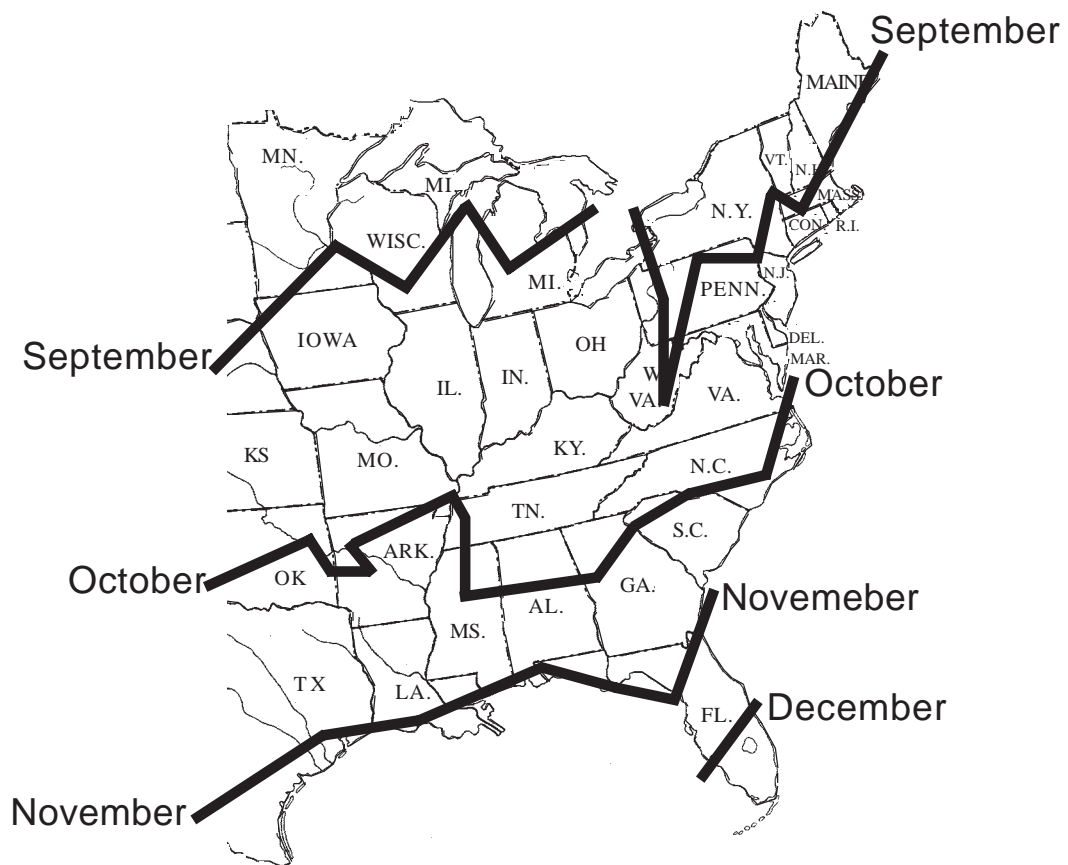


Figure 5: Progression of the average first 32°F temperature occurring across the Eastern United States by the end of each month.

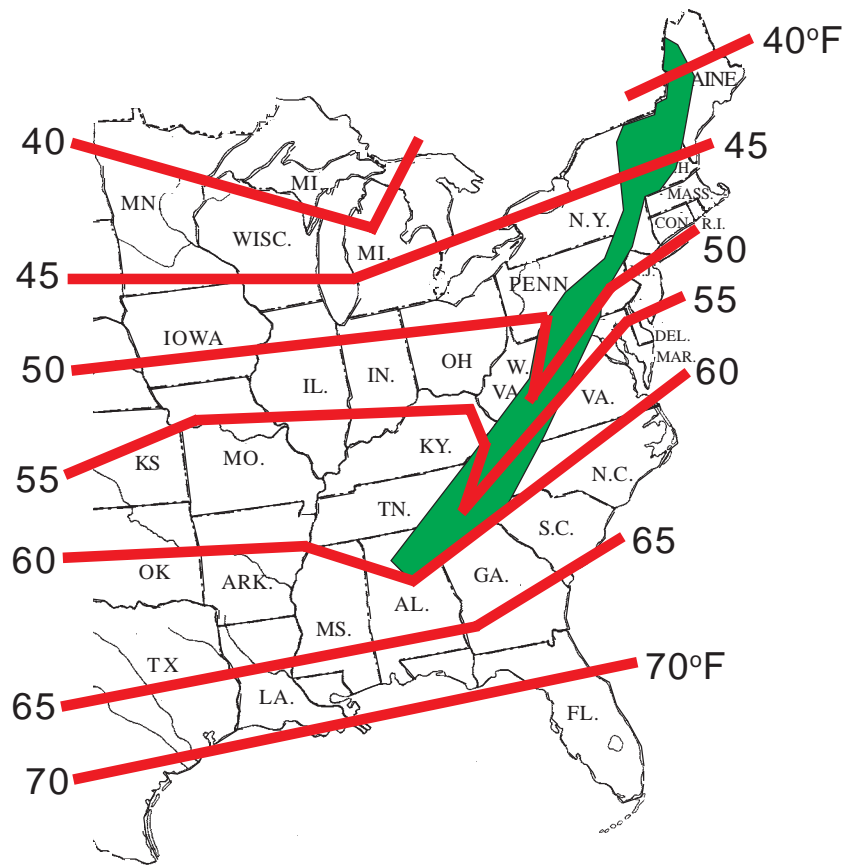


Figure 6: Map providing the area of the Appalachian mountains (in solid green), and the annual average daily temperatures in degrees (°F in red solid lines).

180 for the Eastern United States. This average value of sunshine hours tends to initiate senescence processes in trees. Figure 3 shows the month when the average daily temperature of 50°F is reached in Eastern North America. This average temperature pushes senescence along.

Figure 4 is similar to Figure 3. Figure 4 shows the progression of average minimum daily temperatures of 50°F across the Eastern United States. Figure 5 shows the average first 32°F temperature occurring by the end of each month across the Eastern United States. Figure 6 summarizes climatic and topographic values, showing the Appalachian range combined with the average daily temperatures on an annual basis. Note on Figure 6, it takes between and 1 and 1.5 weeks for color expression to move Southward for every 5°F of average temperature change.

### Prediction Features

Key features of predicting fall tree colors and their peaks are:

- 1) leaf volume -- how many leaves are entering the color season still attached to their trees as compared to normal;
- 2) leaf health -- how damaged and disrupted are leaf surfaces from pest and environmental problems;
- 3) long-range weather forecasts for temperature, sunlight/cloudiness, and precipitation over the color period and the preceding few months;
- 4) actual temperature and precipitation over the last half the growing season, the whole growing season and the previous year's growing season;
- 5) timing and extent of color expression in key species with premature and early leaf senescence; and,
- 6) examining historical records of peak color days from the past decade.

### Catching Waves

To understand landscape-level fall coloration in the Southeastern United States, a simple flow and wave model (Coder Leaf Color Propagation Model) can be used. Coloration changes begin at high altitudes and latitudes, and observationally flow down-slope and southward. Visualizing color waves sweeping over the landscape can help in explaining color changes, and associated environmental changes, occurring in Fall. Tree coloration advances in three primary waves in mixed hardwood forests.

The first wave is yellow dominated. The second wave is orange. The third and final wave is red. Each wave, depending upon location is separated from the next wave by anywhere from six to sixteen days. Most humans consider peak color occurring just as the orange wave sweeps by. After the red wave hits, the landscape slowly fades to brown. Figure 7.

### Color Quenching

As color waves move southward, conditions yielding the best color expression are less and less present and not as strongly impacting on trees. The color waves eventually pass southward and are quenched in the evergreen forests of the Southern coastal plains. As fall progresses, the last pigments fade and the leaves fall away to carpet and enrich the forest floor. Even as this year's leaves are raked, tree buds have next year's leaves set to grow. Life processes continue in the rest of the tree to ensure surviving Winter. Fall colors represent not a last gasp, but a first breath of a new spring. Next year with spring bud break, chlorophyll veils will again come out with Fall colors hidden beneath their surfaces.

### Summary

The best color presentations are the additive effects and good fortunes of both healthy trees and perfect climatic conditions. With so many different events leading to great tree color, only a few years have the perfect combination for best autumn color expression.

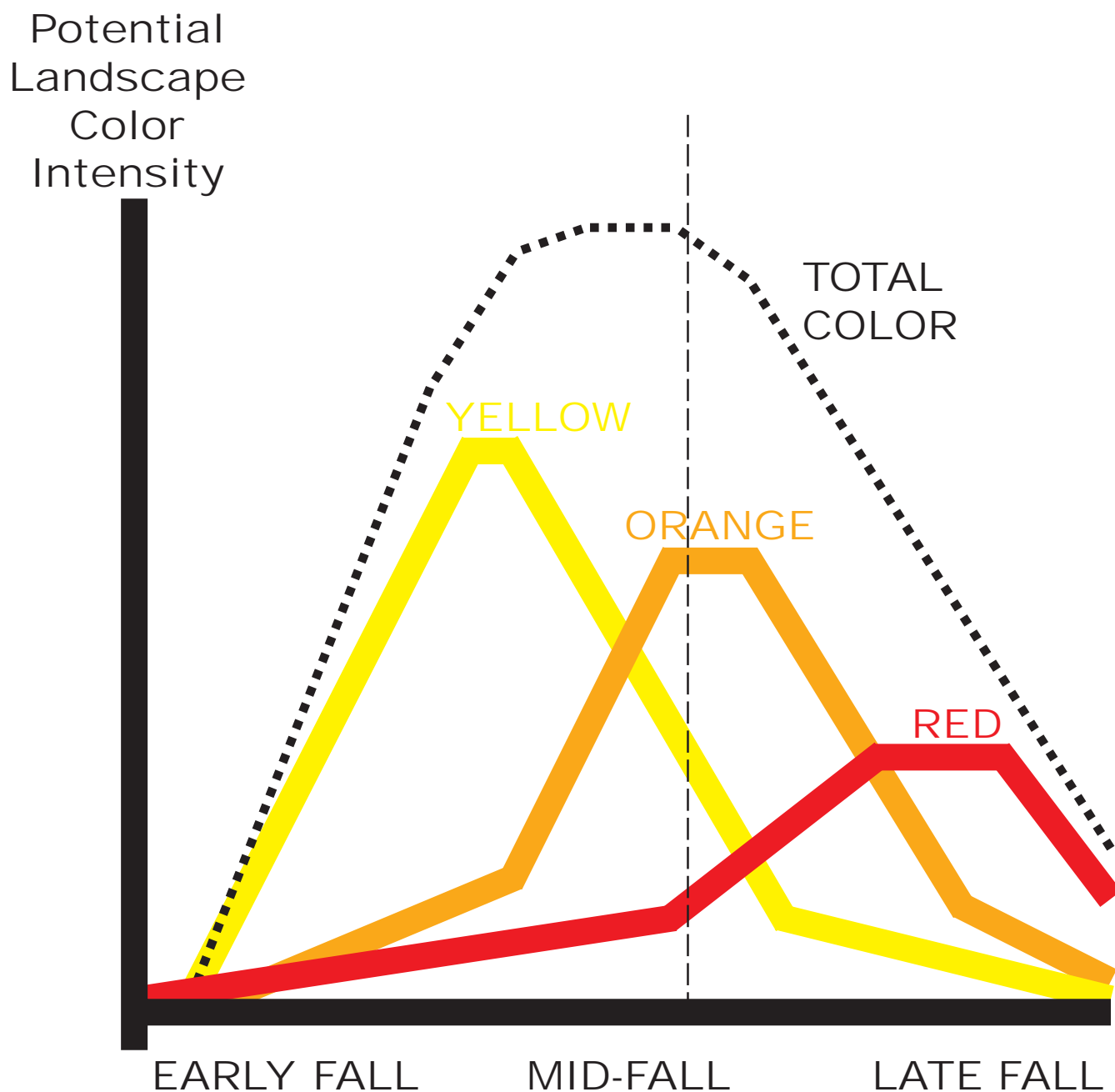


Figure 7: Principle landscape color waves from the Coder Leaf Color Propagation Model. Most people consider peak color at dashed line over the orange peak.