Color Management

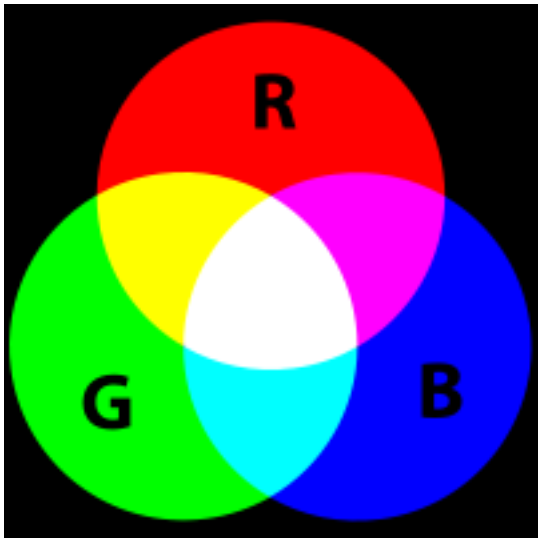
Objectives:

- Understand basic color theory as a foundation for color management
- Understand how RGB colors are defined
- Understand how defining a color space is critical to defining how that color should be displayed
- Understand the limitations of specific color spaces and the gamuts associated with those color spaces
- Understand monitor gamut and the impact on your image editing accuracy
- Understand how monitor calibration and profiles work
- Understand importance of monitor profiling, and how limitations of your monitor will affect your workflow.
- Understand recommended Photoshop settings

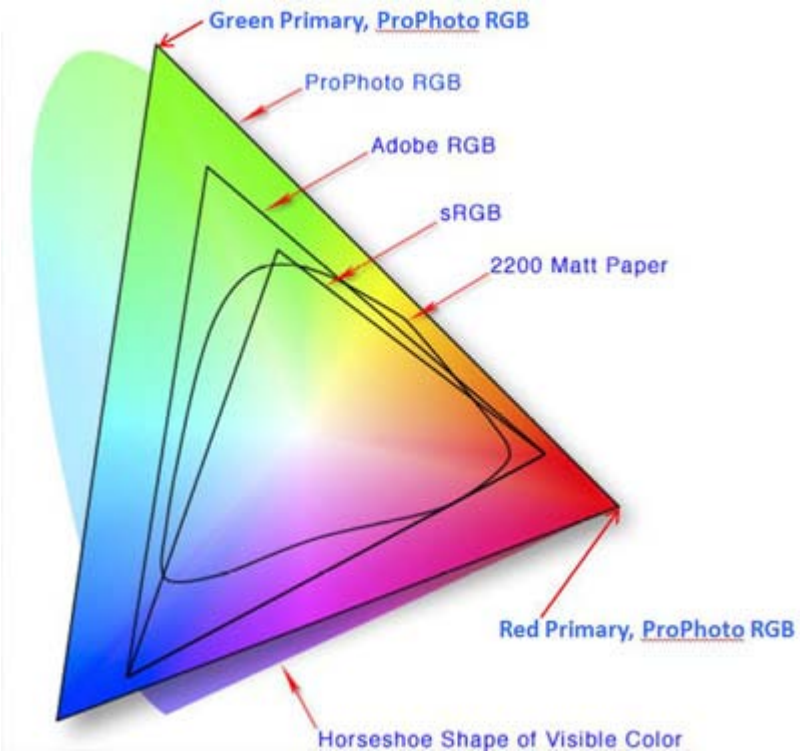
Color Theory Abstractions. Modern color theory is based on two primary abstractions of color:

- Additive color models apply to light emitted from a source or illuminant (such as the phosphors on a CRT screen)
- Subtractive color models apply to colors that are formed by the subtraction (or absorption) of some wavelengths of light and reflecting of the others.
    - Subtractive color systems start with white light. Colored surfaces between the viewer and the light source subtract wavelengths from the light, giving it color. (For example, the CMYK color system used for printing.)

RGB Color Model. The RGB color model is an additive system, and every color within the RGB model is created through a combination of the red, green and blue components.



- A color in the RGB color model is expressed as an RGB triplet (*r*,*g*,*b*). Convention in Photoshop is to represent each color component with a value from 0 to 255 (a legacy based on the number of distinct levels available when using 8-bit encoding).
    - For example: An RGB triplet of 0, 255, 0 will represent the most saturated pure Green.
- The basic triplet by itself however does not define what is meant by red, green or blue colorimetrically. (What exact spot on the color spectrum do you define as “green”?)
- A color space definition is used to define the exact chromaticities (hue or colorfulness) of the red, green, and blue primaries.



- You need an RGB triplet, *and* a colorspace defined in order for your system to properly display color.
    - With a triplet of 0,255,0 and a color space tag for sRGB, the green will be displayed as the most saturated green in the sRGB color space.
    - With a triplet of 0,255,0 and a color space tag for Adobe RGB, the green will be displayed as the most saturated green in the Adobe RGB color space, which is MUCH more saturated than the green in sRGB.

  (On screen Demo using wide gamut monitor: (Caveat: this demo will only be effective on a "wide gamut" monitor capable of displaying a gamut greater than the AdobeRGB color space.)
        - Open the attached colorspace demo.jpg file in Photoshop, "accept" the embedded color space (ProphotoRGB) and view the file onscreen. Note the VERY saturated colors. Display the "info" tab, and moving your cursor over the RGB color patches note that each patch displays a max value of 255 for the primary color.
        - Convert the file to AdobeRGB color space and note that the saturation is "toned down" from the ProPhoto version. While moving your cursor over the color patches, note that the color is still defined as 255 for the primary color defined in each patch (displaying the most saturated primary colors available in the AdobeRGB color space.
        - Convert the file to sRGB color space and note the saturation is even more "toned down." Note again that each color patch is still displayed with a max value of 255, defining the most saturated primary colors available in the sRGB color space.
        - Now *convert* the file back to AdobeRGB. (Use either relative colorimetric or absolute colorimetric "intent". This will preserve the actual colors.) Note that the saturation of the primary colors does not change when converting to a larger color space, and the numeric values displayed in the info tab are not 255 for the primary color, but either a mix of colors or a less saturated value for the primary colors.
        - Convert to ProPhotoRGB and note the same. The color saturation does not change, and the numeric values of the colors are lower on the saturation scale.)
        - Display the "history" palette and select the first "open" step in the history steps. Note the significant change in saturation as the file is displayed again as the most saturated primary colors in the ProPhoto color space.

    - If the software doesn't find a color space tag, then a triplet of (0,255,0) will be displayed as the most saturated green that the monitor can physically display.
- The range containing all the possible colors in a color space is defined as the *gamut* of that space

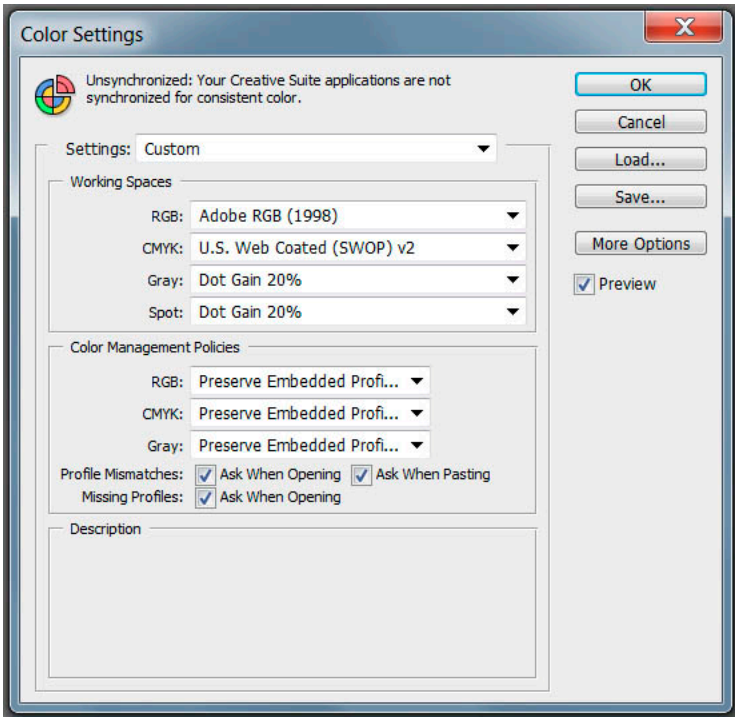
Monitor gamut. Monitor gamut is often describe as the percentage of the sRGB or AdobeRGB color spaces the monitor can display.

- Monitors that have a limited gamut cannot physically display colors that are outside that gamut.
    - If your working space in Photoshop is AdobeRGB, but your monitor only has a gamut equal to the sRGB color space (72% of AdobeRGB), you will be manipulating colors that you cannot see or effectively evaluate
    - Colors contained in the image, but not visible on screen (due to limited gamut) will make it impossible to match print to screen
- Display of colors without a color space tag will be determined by the physical capabilities of the monitor (monitor or device color space), with the range of 0 - 255 being stretched (or compressed) to fit within the montor's gamut.
    - Because different monitors have widely varying physical capabilities, the displayed colors will vary widely for images that do not contain a color space tag.

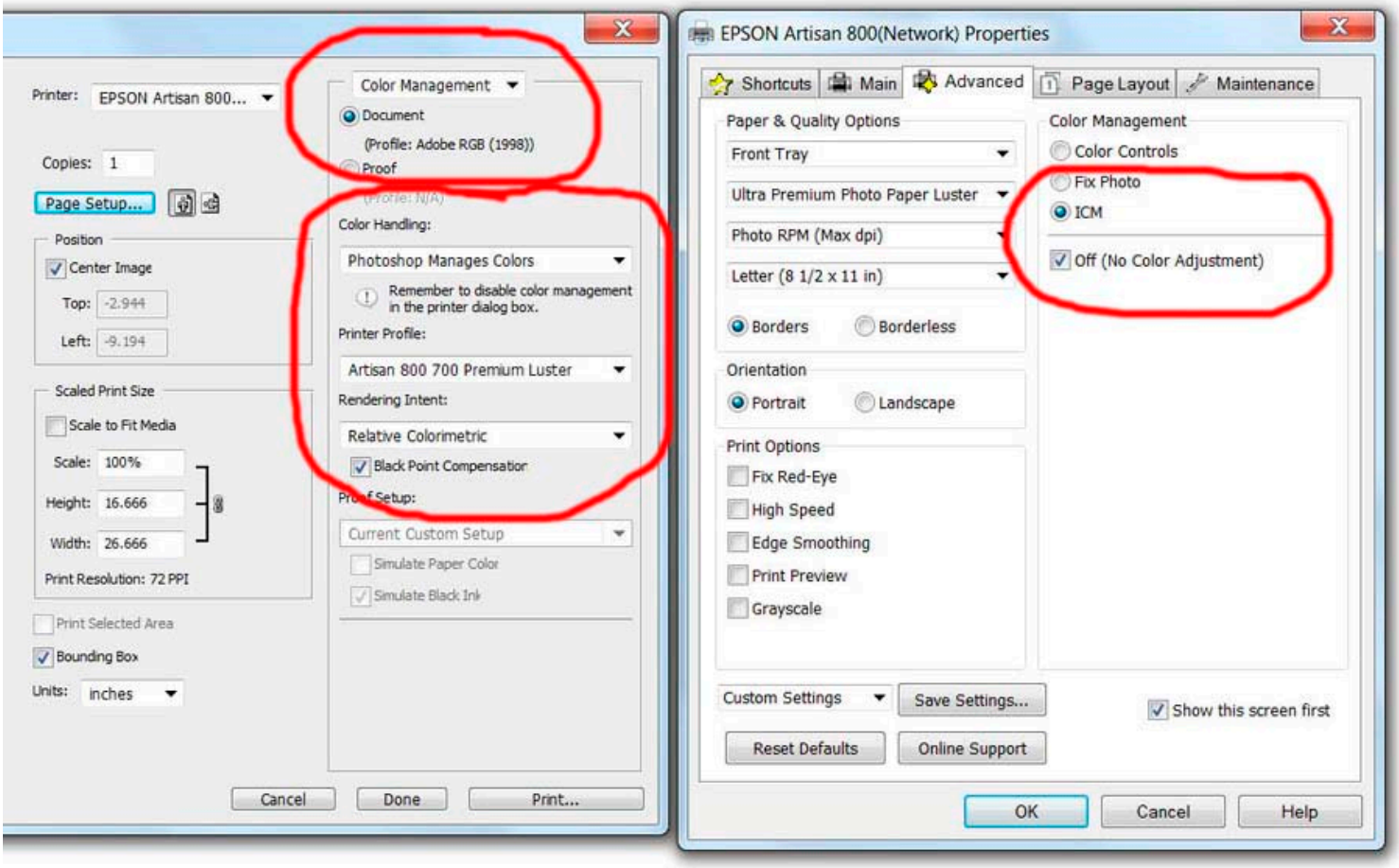
Monitor Calibration. Because monitors with bright saturated colors sell much better than those with "dull" colors, almost every monitor you can buy will have a default "tone curve" that exaggerates the colors and contrast. The only way to display accurate colors is to calibrate or profile your display.

- Calibration: "dials in" the physical characteristics of your monitor to achieve more accurate results. (Adjusts the ratios of rgb guns, etc. Often misused when meaning "profile.")
- Profile: measures the actual color and brightness response of your monitor against known targets, and then makes this profile available to the OS and applications so that they can apply the necessary corrections to display accurate color.

Recommended Photoshop Settings.



Photoshop print settings and printer properties (accessed via page setup on print dialog):



Useful definitions:

Saturation. The saturation of a color is determined by a combination of light intensity and how much it is distributed across the spectrum of different wavelengths. The purest color is achieved by using just one wavelength at a high intensity, such as in laser light. If the intensity drops, so does the saturation.

references: bestflow.org, wikipedia