

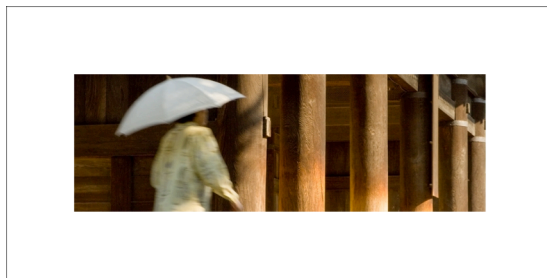
## Color Perception & Color Management

### The Transmissive vs. Reflected Light Conundrum

Digital color photographic images are viewed and critically evaluated with transmissive light, and these images possess luminous color properties that are not revealed to the human eye when viewed in print form, with reflected light. We can simulate what a print might look like on a monitor with a procedure known as *Soft Proofing*, using ICC Printer Profiles, and form speculations of its actual appearance, but due to the inherent physical properties of each viewing system, a perfect match is impossible. *What you see is what you get* [WYSIWYG] is the objective, but this great color conundrum never gets fully resolved. Making these two visual systems produce reliable results requires developing color management skills, and a workflow to keep digital files that move across different devices appearing consistent and accurate.

### Monitor Color

Liquid Crystal Displays [LCD monitors] produce images viewed with transmissive light, and use the **additive color** system of light. Red, green, and blue is channeled to the eye via pixels. Each pixel is assigned numbers for RG&B that define its hue, saturation, and luminance.



### Print Color

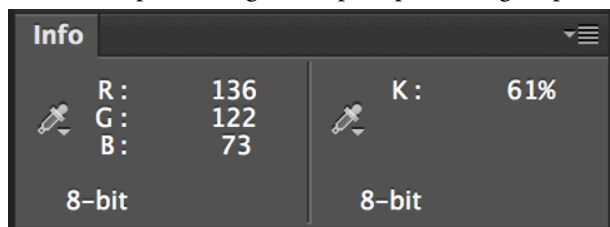
Inkjet printers produce images viewed with reflected light, and use the **subtractive color** system with pigment. Cyan, magenta, yellow, & black sprays onto paper in microscopic ink dots: **info that is converted from pixel data**. Reflected light from the surface meets the eye and based on a paper's tactile characteristics, changes occur to density, contrast, color, and detail. It's important to know this relationship between pixel processing, color management, and the potential consequences in print output.

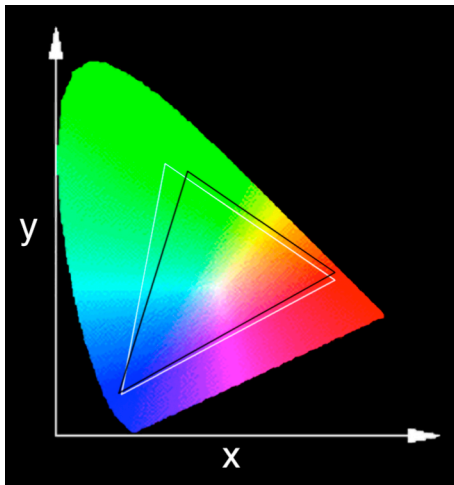
### A Pixel Revealed in the Info Palette

Numbers assigned to a single pixel in this image have produced a middle-tone yellow. Photoshop displays RGB as 8-bit, from 0-255; & Lightroom as 0-100%, since bit depth is assigned in post-processing [export].



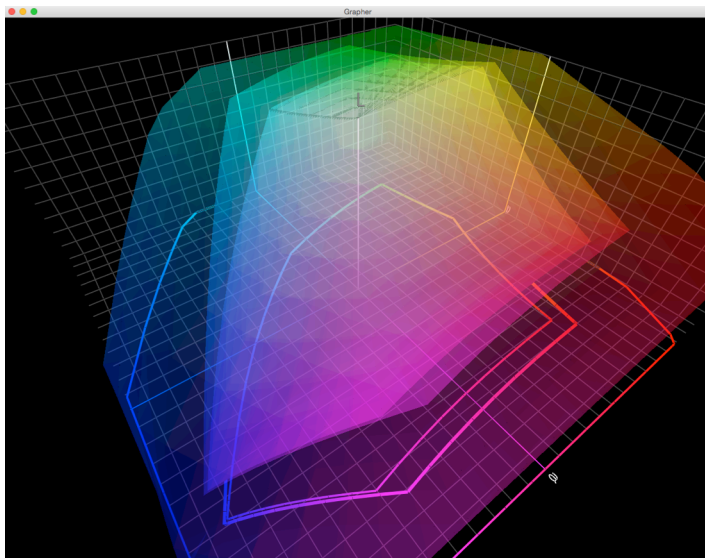
Top image is Red Channel only; Middle image is Green Channel only; Bottom image is Blue Channel only.  
©2005 Don Werthmann — Tenju-an Temple, Kyoto





**CIE** — *Commission Internationale de l'Éclairage*. In 1931, this organization created a color standards model **based on human perception**. It characterizes visible light by plotting on X and Y axes. A specific intersection of each axis creates coordinates to map a color with respect to hue, saturation, and luminance. Points on the edge of the horseshoe shape denote pure color of specific wavelengths of visible light. It is an additive color model where the point of white found at the center indicates where all colors combine equally, or what is also known as daylight [5500 Kelvin]. CIE, which is similar to LAB Color, serves as a benchmark for color gamut when attempting to match or convert colors from RGB to CMYK. **It is device-independent.**

The **CIE Chromaticity Diagram**, and the *approximate* location of two color spaces used in digital, color image processing [above]. The black triangle represents the color gamut produced on an Apple LCD Display; the white triangle represents the Adobe RGB (1998) working space, which is a mid-range color gamut used in the photo industry for printing.



### What are Color Spaces?

Color spaces are mathematical models that describe color with an ordered list of elements—RGB [3] | CMYK [4]—known as a tuple. The idea of a *color space* is clearly evident when rendered three-dimensionally [left], instead of two-dimensionally as illustrated above.

The illustration compares the three most common **color work spaces** that reside in a 3-D, LAB coordinate grid. Large to small they are, ProPhoto RGB, Adobe RGB (1998), and sRGB IEC61966-2.1.

**ProPhoto RGB:** Superior working and processing color space for inkjet prints.

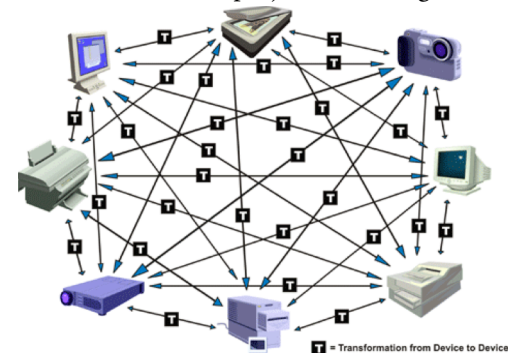
**Adobe RGB (1998):** Excellent working and processing color space for inkjet and some service bureau prints.

**sRGB...:** Adequate to deliver images for most service bureau prints, Internet use, or other monitor / projector viewing.

### What is Color Management?

Based on human perception, **LAB Color** represents visible light, therefore it's device independent, and it's the *Profile Connection Space* [PCS] used to translate color between all digital devices. The L-axis is Luminosity, white-to-black; the A-axis magenta-to-green; & the B-axis yellow-to-blue.

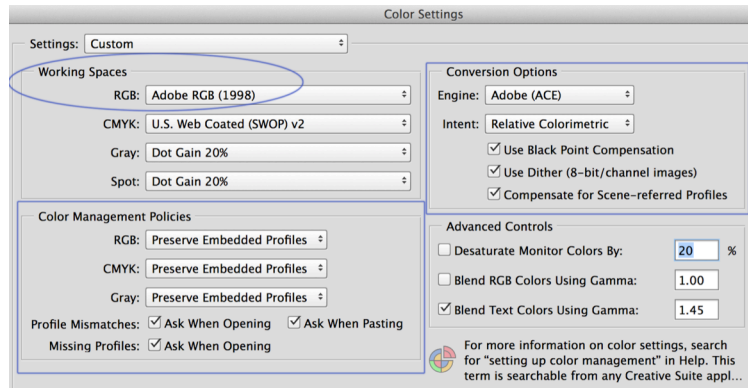
Color management defines an idea of developing workflow to keep digital files moving across different devices looking consistent, such as from capture device [camera | scanner], to monitor [Mac | PC], to projector, and to various kinds of print outputs [inkjet, service bureau, commercial press].



## Setting the Working Color Space in Photoshop

Go Edit > Color Settings... the illustration [right] shows how Photoshop is set up on all of the WCC Photo Lab Macintosh Computers.

**NOTE:** Set up Photoshop the same way on your own computer to reduce the possibility of unintentionally converting an embedded color profile that's in a working version of a file.



## Why Use Camera RAW?

- It's unprocessed data, direct from a sensor, offering ability to make wide modifications of white balance, exposure, contrast, color, and more, without forfeiting quality.

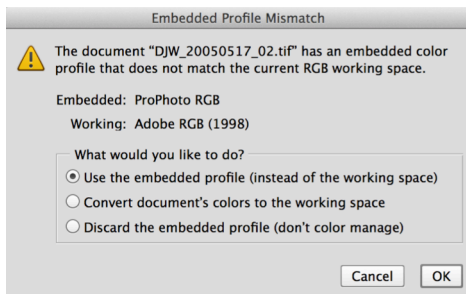
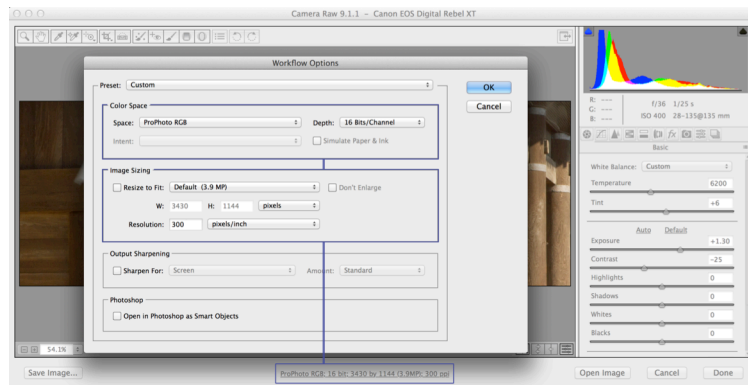
- Enables re-interpretation that's non-destructive to the original image data captured.

- The only camera settings that have an effect on pixels captured are ISO [sensitivity], aperture [intensity], and shutter speed [time].

- Assignment of Color Space, Bit-depth, and Resolution in a Camera Raw Processor [above] before commitment to processing and opening image, to create a working version of the file.

- 12-bit dynamic range that enables 4,096-step grayscale per pixel. [JPG is only 8-bit].

- Disadvantages of Camera Raw include producing larger file sizes per image; the reduction in the number of images that can be saved on a storage card; camera operations slow down; and impacts to productivity, because additional time must be allocated to process images.



## Color Profile Conversions — CAUTION

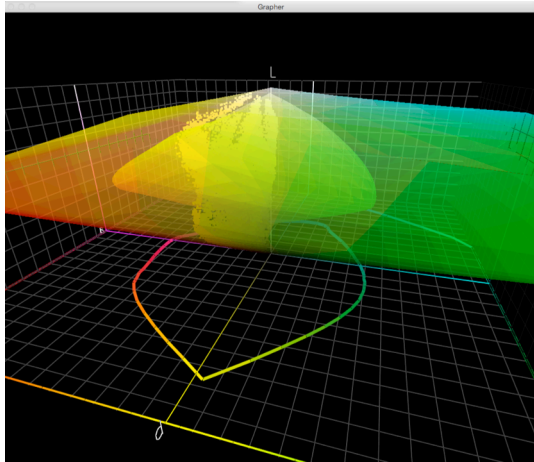
Committing to Save As... [exporting] .TIF or .PSD from Camera RAW, must be considered permanent for the entire life span of the image. **In general, always keep the Embedded Color Profile and the Bit Depth the image was originally assigned.**

If a large color space is converted to a smaller space and saved, then the unused color info gets deleted. Although doing this is acceptable, what's destructive is re-converting the image, from the smaller to the larger space in the next work session. The re-conversion doesn't restore the original, available color gamut, but instead interpolates [invents] color information by means of estimation.

**If a conversion is required**, then save a different version of the file once a destination device is determined, like for Internet [monitor], inkjet, service bureau or commercial printer, etc.

## Why not shoot JPG?

- It's data processed on board the camera possessing a limit of 8-bits per channel, per pixel.
- Mathematical compression throws away a large amount of data captured: about one-stop of usable dynamic range, and there's no control over what gets discarded.
- A color profile is determined in camera, which offers fewer options for further processing.
- To the uninformed user it is a very destructive format. Saving a JPG capture, as JPG again, degrades image quality because data compression occurs each time.



## Using ICC Printer Profiles

International Color Consortium [ICC] print profiles are device dependent documents that characterize the color capabilities of a printer, instructing how to manage a digital file sent to it, including data about the type of media and ink used. The Epson profiles used in WCC's Digital Labs are designed to work with a specific printer model and paper type. Choose the one identifying the Epson paper being put in the paper tray.

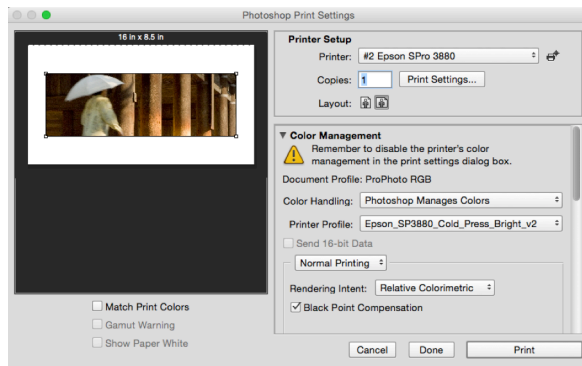


Name SC-P800 Series Cold Press Bright MK v2.icc  
Kind ICC Profile  
Size 2.5 MB

Illustrated above from large to small, ProPhoto RGB; Epson P800 ICC Profile, Cold Press Bright Paper & Matte Black [MK] ink; and the image data map of Tenju-an Temple relative to the two color spaces. Note an obvious deficiency of available color this ICC Printer Profile has, compared to ProPhoto RGB, and then, how some image data is present outside of the ICC Printer Profile space. These out-of-gamut colors are managed by the Rendering Intent.

## Rendering Intent

Rendering Intent in the Print Dialog [below] determines the method [algorithm] used to convert RGB Color to CMYK Color, using a Color Matching Module [CMM]; software that maps colors between devices. *Perceptual* preserves the visual relationship between colors but compresses and shifts their location, whether out-of-gamut, or not. *Relative Colorimetric* shifts only the out-of-gamut colors, leaving in-gamut colors alone. **It's important to try both methods, and compare.** Writing notes on test prints, and tracking the various settings used is strongly recommended since the inspection process might offer only very subtle differences, whereas at other times the differences can be very surprising. Comparison breeds experience!



## Print Settings

These last few steps of the color print workflow are riven with the potential to make mistakes. Take time to read & use printer Help Documents in the WCC Digital Labs to get a solid understanding of the several variables presented there. Settings must be correct to produce a technically accurate print. This Print Dialog [left] is only an example and is provided for reference, not workflow.