RAW, sRGB or Adobe RGB (1998)? The contention over how to capture data with your digital camera is flooding photo-centric Web sites.

The great color space debate

Figure 2. Adobe Camera Raw offers four RGB working spaces for conversions from RAW grayscale.

The arguments over the best settings for data capture with digital sensors show there's some serious misinformation out there. Because the choice of settings ultimately controls how color is produced and converted into color spaces, this is most certainly a color management topic.

All single-shot, single CCD and CMOS sensors today are monochromatic, meaning they record only a certain intensity of light; essentially, they're colorblind. When a mosaic of colored filters is placed over the individual sensors, a process called *stripping*, each sensor produces a pixel that records or "sees" only red, green or blue information *(see Figure 1)*. What this produces is really a grayscale file of **RAW** data.

The full color information of the file is generated post capture, either in-camera or on computer with a RAW converter application. Depending on the options you select, the file is encoded into some RGB color space. In-camera, the color space options are usually sRGB or Adobe RGB (1998). On the computer with a RAW converter application, the options include both of these, plus others. The Adobe Camera Raw plug-in, for instance, provides a choice of four RGB working spaces *(Figure 2)*. In addition to color space options, you have control over grayscale-to-color conversions, with respect to tone, saturation and color.

We've seen that the important difference among the more widely used and supported RGB working spaces is the color gamut, the range of colors and tonality a device or color space is capable of containing. Some so-called experts suggest that the sRGB color space, with the smallest color gamut, is just fine, even for professionals, because no printers can produce a wider gamut of colors. This is nonsense, as illustrated in *Figure*
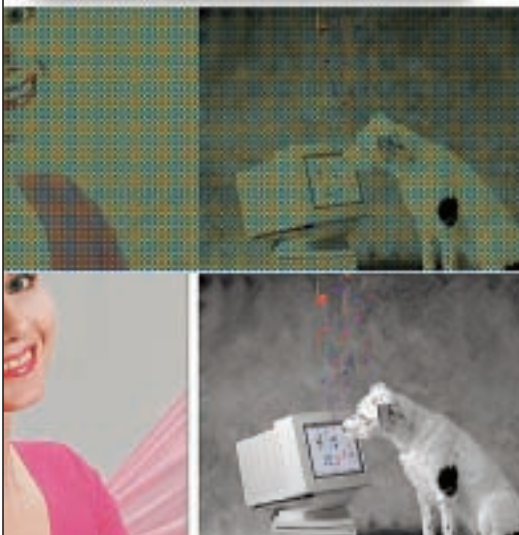

Figure 1. An example of how a stripped CCD "sees" color. Top—a Bayer pattern of colored filters over individual CCD sensors; middle—how an image looks before demosaicing; bottom—the true color after demosaicing.

3, a simple examination of a gamut map. RGB working spaces like sRGB, Adobe RGB (1998) and ProPhoto RGB are synthetic color spaces based on simple numeric values for the gamma, white point and chromaticity. When plotted out as in *Figure 3*, they all have a simple shape. But digital printers' gamut maps don't produce such simple plots; commonly, many colors fall outside this simple shape. The colors that do fall outside are out of gamut, and cannot be reproduced on the output device. If such saturated colors are important to the image, they will be clipped to the closest in-gamut color of the working space.

Adobe RGB (1998) has a significantly larger color gamut than sRGB. *Figures 3* and *4* show the gamut of a four-color press—the Photoshop U.S. Web Coated (SWOP) v2 profile—plotted over both Adobe RGB (1998) and sRGB. As you can see, many of the saturated cyans and greens within the color gamut of the press fall outside the sRGB space, but are fully contained in Adobe RGB (1998). Many inkjet and photo printers have a color gamut significantly larger then a four-color press. If you shot an image for which the eventual output would be this press, and if the greens, cyans and other colors were important, sRGB would not afford the use of the full gamut of the printer,

because these colors cannot exist in sRGB. Obviously, the color gamut of the image plays a role in its reproduction. Photograph a pastel scene, or maybe a setting of silverware in both sRGB and Adobe RGB (1998), and likely there'd be no difference in the output because the image itself contains no saturated colors.

There are some disadvantages to using a working space with a wide gamut like Adobe RGB (1998). The gamut of your display, like all devices, is fixed. With the exception of some of the new and expensive LCDs and CRTs, display systems have a much smaller gamut than Adobe RGB (1998). How could you accurately edit a color image with a gamut larger than your display's? If the saturated colors in the image file cannot be fully displayed on your screen, editing and soft proofing will be difficult. The problem will eventually be resolved when wide-gamut displays become affordable.

Very wide gamut spaces like ProPhoto RGB and Wide Gamut RGB should be used only with images containing more than 8-bits per color (in Photoshop, 16-bits per channel). As the gamut of a color space widens, the space between the bits spreads out; if you're working with only 256 values in a color space with a very wide gamut, any editing you do to the image could result in banding. Virtually all RAW files can be converted to more than 8-bits per color, while all RAW-to-JPEG conversions only to 8-bits.

Though the gamut of Adobe RGB (1998) is wide, most digital camera systems have the capability to capture a far wider gamut. The main drawback in selecting sRGB as the final RAW-to-
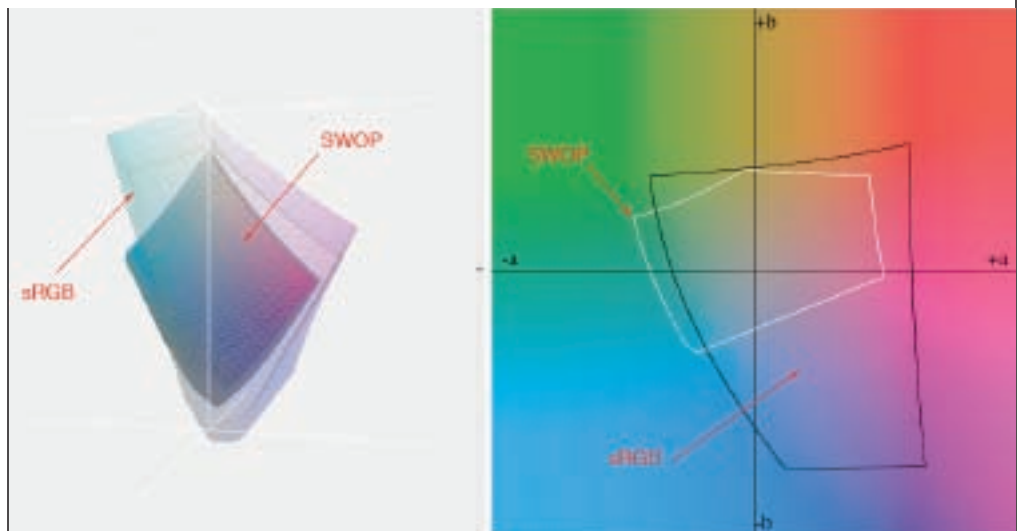

Figure 3. A screen capture from MonacoGamutWorks utility, showing a 3D and a 2D gamut map. The left pane is a 3D map of sRGB compared to SWOP. The gamut of sRGB is smaller, and a significant area falls outside the SWOP gamut. This is obvious on the 2D plot, where the white line extends outside SWOP in the green range.
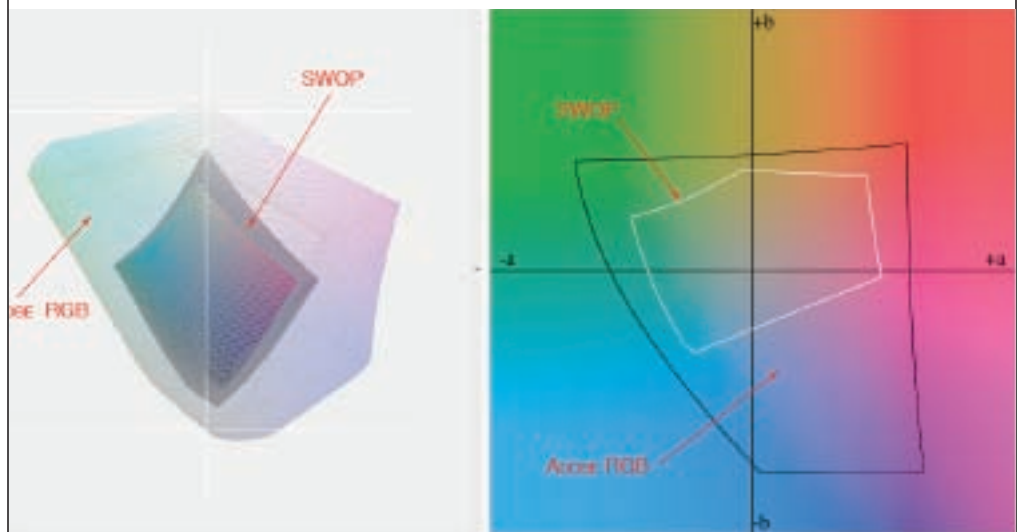

Figure 4. The SWOP gamut is fully contained in Adobe RGB (1998). Keep in mind that most photo printers have a larger gamut then SWOP.

color space is that once the shutter snaps, the color is forever encoded as sRGB. Any colors beyond the sRGB gamut that might have been useful are now forever unavailable. With Adobe RGB (1998), there's at least the potential for the image to contain more color data.

Have you heard some "expert" say something like, "With many cameras, using Adobe RGB yields no direct benefits, and could even be counter-productive, in producing slightly duller colors before processing." That's incorrect if both color spaces are properly handled in Photoshop. In fact, the two files should look nearly identical, even though the color values are different.

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Dull looking colors are the result of incorrect color management of untagged files. With most digital SLR systems, the capture files do not have embedded ICC profiles, but instead have embedded EXIF data, which tries but sometimes fails to inform Photoshop about the color space it was captured in. If you do set your camera to convert the data into Adobe RGB (1998), be sure that Photoshop recognizes this, and be ready to use the Assign Profile command to select the matching color space, Adobe RGB (1998), to actually embed the image with an ICC profile. Now the colors will appear correctly.

The beauty of RAW data is that it contains no color. It's like digital clay waiting to be shaped by the photographer. When you set your digital camera to provide sRGB or better yet, Adobe RGB (1998), the color rendering and encoding is fast but permanent, and you have no control. Unless the camera has a capture mode like RAW + JPEG, the RAW file is converted to the color space you ask for, and the original RAW data is discarded. The downside to RAW is you need to process each image, which is time consuming, and that the amount of time and the quality of the final image is significantly affected by the particular RAW converter software you use.

The RAW file contains all the data the camera's sensor is able to produce. For many photographers, it makes sense to archive images with all of the RAW data, while for others, it makes more sense to let the camera process the color. The call is yours, but beware of the advantages and disadvantages. With a RAW + JEPG capture setting, the color matrix settings selected on the camera will be used to create the JPEG. The histogram displayed on the LCD represents the RAW-to-JPEG conversion, not the RAW data. ■