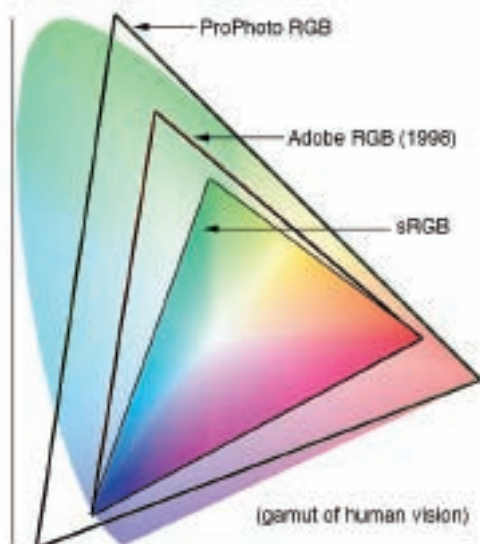# The RGB working space debate

A recent article on the ProPhoto RGB working space published on a respected photo-centric Web site was clear and concise about the RGB working space (http://www.luminous-landscape.com) Dozens of posts to other photo-centric Web forums, however, revealed confusion about this working space, bringing to light some persistent misconceptions. I'll see if I can clarify a few of the important points.

One common misconception among photographers is that their digital cameras produce either sRGB or Adobe RGB (1998). These shooters do not recognize the role of the RAW data file their camera systems produce. A RAW file is just that—raw. It's essentially a grayscale data file, proprietary in nature (a huge issue in itself) that needs to be rendered and encoded into a color space (see my column of February 2005). The important point here is that a RAW data file can be encoded into any RGB color space you wish.

In the Web article, the author presented some good reasons for using ProPhoto RGB, which I'll go into later. What's key is that you, the photographer, have the option to let the camera produce RGB data from the RAW file in either sRGB or Adobe RGB (1998), or to handle it yourself using a RAW converter and a different RGB working space.
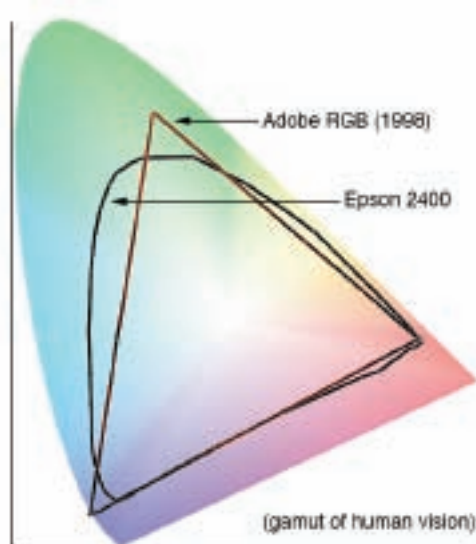
The primarily difference between one RGB working space and another is the color gamut, the range of color and tone it can reproduce. "Color gamut" is a fine term for describing output devices, but not necessarily for input devices such as scanners and digital cameras. Scanners and digital cameras do not have a fixed color gamut boundary, per se, but what can be described as a color mixing function. The filters used in both devices do have limits on what they can capture, but the scene itself and the film or print image of the scene do have a fixed color gamut and dynamic range. Say you photograph a gray card and then go photograph a field of highly color-saturated flowers with the same digital camera. The camera's sensor is capturing differing ranges of color data. The color gamut of the scene itself is different.

In considering the most appropriate RGB working space to use when converting RAW data, the scene will play a role in what you can first capture, then contain in the encoded file. Many users say they see no difference when they shoot and automatically convert into sRGB versus Adobe RGB (1998), yet the scene does play a role.

The color gamut of the output device plays a role as well. The color gamut of a display is pretty small—very close to sRGB (unless you can afford the few Adobe RGB (1998) size gamut displays hitting the market). Your printer may have a gamut that cannot take advantage of the gamut you captured from the scene. There's a great deal of interplay between scene, working space and output space gamut.

One of the best tools for examining the gamut of a scene and selecting a working space for all Photoshop users is

Figure 1: Two-dimensional gamut plots of three popular RGB working spaces. The entire horseshoe-shaped plot represents all visible colors. Note that ProPhoto RGB describes colors outside of human vision.

Figure 2: The gamut plot of an Epson Photo Printer 2400 on glossy paper in reference to Adobe RGB (1998). Notice how some of the yellows and a good deal of the greens and blues fall outside the plotted gamut of this working space.
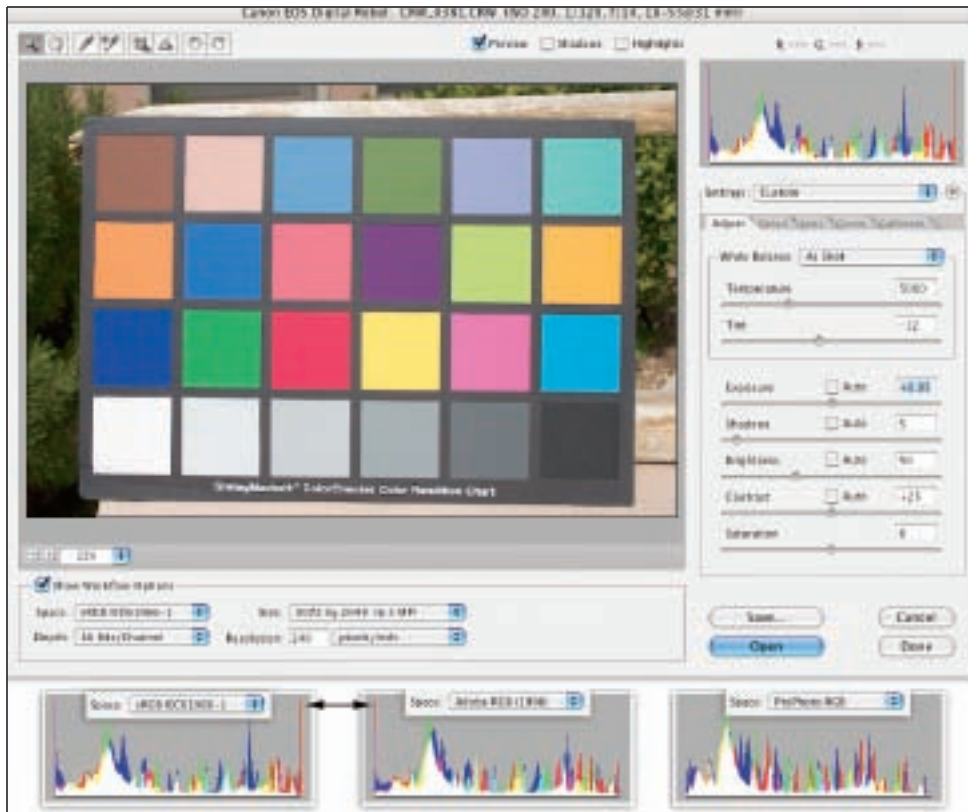
Figure 3: Adobe Camera Raw reflects a series of histograms of the GretagMacbeth ColorChecker as shot with a Canon EOS 300D. In sRGB, the first histogram, the saturated colors are clipped at both ends of the scale. Fewer colors are clipped in Adobe RGB (1998), but none in ProPhoto RGB, due to the size of its color gamut. A single color seen butted on either end indicates saturation clipping (white indicates clipping in all three channels). In the sRGB histogram, the magenta clip on the far left indicates that neither red nor blue colors are clipped, but green is, and on the other end, red is clipped.

Adobe Camera Raw software. The histogram in Camera RAW updates on the fly as you select different RGB working spaces. You're given only four to chose from, three of which we've already discussed, sRGB, Adobe RGB (1998) and ProPhoto RGB. **Figure 1** shows a two-dimensional gamut map of these color spaces.

You can view gamut maps all over the Web, so let's take a quick look at what they represent. The horseshoe-shaped outline represents the gamut of human vision. If you plot the colors in this outline, they represent the limit of the colors we can see: the pure spectral colors of visible light. We cannot see any of the colors represented by the points outside of the horseshoe. The three

triangular shapes represent the gamut of the three RGB working spaces we've discussed. Because of how the pure primary colors (red, green, blue) are plotted in RGB working spaces, they all have this familiar simple shape.

Note that most output devices have vastly different and dissimilar shapes, which presents a slight problem when you want to fit them entirely within the simpler shapes of a working space. **Figure 2** shows the two-dimensional shape of the plotted gamut of of my Epson Photo Printer 2400 as compared to the Adobe RGB (1998) working space. Some of the plotted gamut of this output device fall outside the color space, which tells me that this working space can't fully contain

all the colors I might be able to print. It's not something to lie awake worrying about, but to simply be aware of.

Now let's look at Adobe Camera Raw. I took a photograph of a GretagMacbeth ColorChecker with my Canon EOS-300D Digital Rebel. It's hardly the most saturated image I could find and the color gamut isn't enormous, but it is colorful. In **Figure 3,** compare the histograms of the image in sRGB, then Adobe RGB (1998) and finally ProPhoto RGB. Neither the sRGB nor the Adobe RGB (1998) working space can fully contain all the colors of this scene, captured with this camera, in this lighting. The sRGB histogram shows clipping of colors on either side, but that's not the case with ProPhoto RGB. So with this set of circumstances, if I want to fully contain all the colors of this scene for use later, I should pick ProPhoto RGB. That's not to say that picking even sRGB will ruin the image, but it wouldn't give me all of the colors I *could* have at my disposal.

Yes, there's a downside of using ProPhoto RGB, and for that matter, all wide gamut spaces. First, its gamut exceeds the gamut of your display. You might have captured all the colors in the scene, but you won't be able to see the most saturated colors on your display. This *could* cause problems when you edit the image in Photoshop, because you couldn't see the actual results of your corrections until you output the file. The output device would have to have a wider gamut than your display, or else you wouldn't see anything anyway.

Another drawback of editing in wide color spaces is the limitations of working with 8-bit-per-channel image files. Eight-bit files have only 256 steps from black to white in each color channel. The same file in sRGB would still have only has 8 bits per color, but in the ProPhoto RGB file, the bits have to be further apart. Look at **Figure 1** and imagine you have to describe all the colors in the largest and smallest triangles in just 256 steps. As you edit the file, the wide-gamut data can exhibit *posterization*, or more accurately, *aliasing*. So, when working in wide-gamut working spaces and using a product like Camera Raw, be sure to bring the data into Photoshop with 16 bits of data. Once the file is edited and ready for output, you can send the print driver an 8-bit file, which Photoshop can do for you automatically when you use the Print with Preview command. ∎