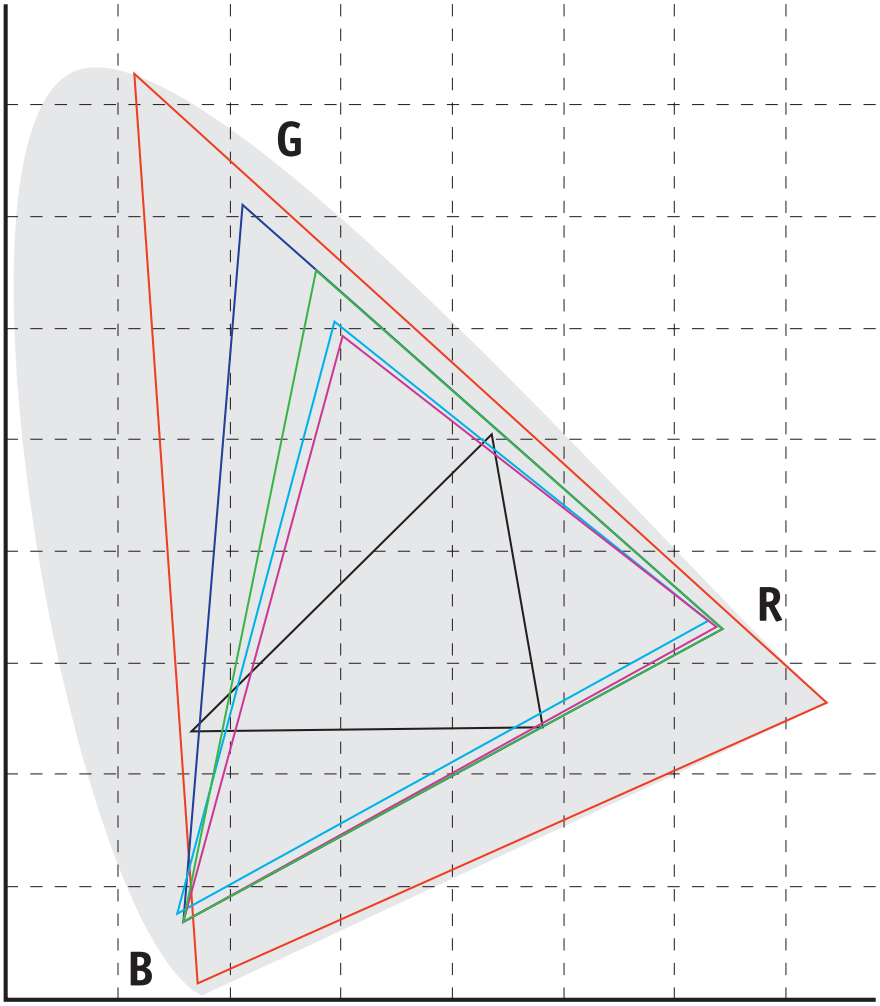
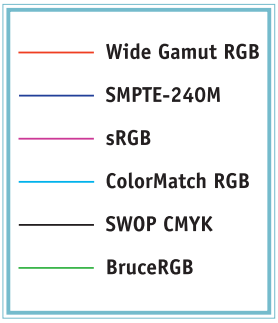
How-to

BY BRUCE FRASER

The Full Gamut. Getting the most from Photoshop 5.0's new RGB working spaces



The gray area in the chart represents the gamut of RGB colors visible to the human eye—at top left are the greens, bottom left blues, and bottom right reds. The smallest triangle at center shows which of those colors can be reproduced in CMYK; the other triangles show the gamuts of various RGB working spaces.



Adobe Photoshop 5.0's new color architecture can help you get much more consistent, predictable color than ever before. But to benefit fully from Photoshop's new capabilities (and get the results you expect), you'll need to master the concept of the RGB working space—the cornerstone of Photoshop 5.0's new color architecture—so that you can adjust some settings to better suit your workflow.

If this scares you, don't worry. This article will explain RGB working spaces and their benefits, help you to choose one that suits your work, and show you how to deal with legacy images. To get the most from this discussion, you'll need a basic understanding of color management (which we don't have space to cover here). If you'd like a primer, see "Color Under Control" in the September/October 1995 issue of *Adobe Magazine*. Other good resources include the ColorSync Web site (*www.colorsync.apple.com*) and Adobe's technical guides (*www.adobe.com/supportservice/custsupport/techguide.html*).

How it used to work

Versions of Photoshop prior to 5.0 always assume that RGB values represent the colors displayed by your monitor, and send the RGB values in the file directly to the screen. This has the advantage of simplicity—if your Monitor Setup information is accurate, Photoshop knows what colors you're seeing on the monitor and uses that information as the basis for its conver-

SMPTE-240M. Below is our test image, edited in the SMPTE-240M RGB working space, after conversion to CMYK. The saturated cyans, blues, and greens were somewhat compromised in the conversion, but that's inevitable—some of those colors are outside the CMYK gamut.

To create the illustrations shown on this spread, we began with an RGB image that we edited in the SMPTE-240M RGB working space. We saturated the cyans, greens, and blues by using the Curves dialog box (we decreased red and increased blue and green, particularly in the highlight areas). We saved our test image in RGB mode.

PhotoDisc

sions to CMYK, Lab, and grayscale. But this approach has three significant disadvantages.

First, it limits your colors to those the monitor can display. Film and high-quality digital cameras can capture a much wider range of color than monitors can. Monitor gamuts vary, but virtually every monitor clips some of the gamut—the range of reproducible color—that can be achieved with CMYK printing, particularly in the cyan region. Using the monitor as the RGB space compromises the reproduction of cyans, blues, and greens.

Second, monitor spaces are not perceptually uniform, so the same editing increment in Levels, Curves, or Hue/Saturation may produce a barely perceptible change or a large jump in different parts of the tonal range. This limits editing flexibility.

Finally, when you take Preferences settings for brightness/contrast and individual viewing environments into account, each monitor is basically unique. This makes it difficult to move files from one machine to another while maintaining color consistency. Embedding an ICC monitor profile in the image provides a partial solution, but the image still gets adjusted ("transformed," in color-management parlance) each time it's opened on a new machine. After a fairly small number of such transformations—four or five—the image can become severely degraded.

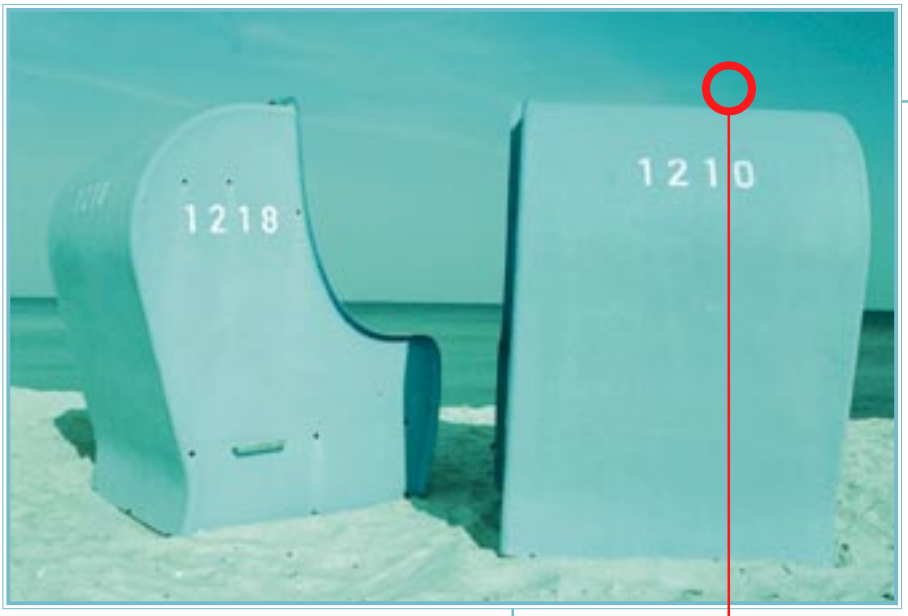
How it works in Photoshop 5.0

Photoshop 5.0 lets you address all three of these issues by uncoupling the RGB space from the monitor. In Photoshop 5.0, you can choose an RGB space independent of the quirks of any particular device—one with a large enough gamut to encompass all of your color input and output devices, and one that's perceptually uniform for maximum editing flexibility. You can standardize on a single RGB working space for your workgroup so that you can move files around seamlessly from machine to machine.

By default, Photoshop 5.0 tags RGB images with the profile of the RGB working space. If you move a file to a machine that has a different RGB working space specified, Photoshop will offer the option of converting the image into the new one. These conversions are quick and very nearly lossless, so there's no reason to be afraid of them.

Since the working RGB space is no longer based on the monitor, the display will be inaccurate unless you use Photoshop's monitor-compensation feature, which does an on-the-fly transform—for display only—from the working space to your monitor's space.

To do this, Photoshop 5.0 needs an ICC profile for your monitor. In Windows 95 and NT 4.0, there is no facility for setting a systemwide monitor profile, so Photoshop looks to the Adobe Gamma Control Panel to provide this information. (See Photoshop Q&A in this issue for information on installing Adobe Gamma in Windows NT.) In Windows 98, ICM 2.0 provides the ability to set a systemwide monitor profile, but Photoshop still looks to Adobe Gamma for this profile,



sRGB. Here is our test image, originally edited in SMPTE-240M (a fairly wide RGB space), after being converted to sRGB (a fairly small RGB space) and then converted to CMYK. Notice how much less saturated the cyan highlight areas are compared to those in the image edited in SMPTE-240M (facing page).

The circled area in the image above (which went through the sRGB space) registers 74 percent cyan, 0 percent magenta, and 38 percent yellow. The same area in the SMPTE-240M image (facing page) is 89 percent cyan, 0 percent magenta, and 46 percent yellow.

which it will then use for monitor compensation. On the Mac, Photoshop looks at the ColorSync System Profile. You can also fine-tune the calibration and create a new monitor profile using Adobe Gamma.

Photoshop 5.0 offers two methods for bringing images into the RGB working space. First, it can open the image with no conversion. With this method, the RGB numbers representing each pixel in the file are unchanged, but the definition of those values—the actual perceived color those numbers represent—is whatever the RGB working space says they are. This is analogous to the old Photoshop behavior, where the RGB values get defined based on your monitor setup.

Second, Photoshop 5.0 can convert the image into the working RGB space. If the image contains an embedded profile, or if you know where the image originated and have a profile available for the image's source color space, you can have Photoshop convert the image from its original color space to the working RGB space. For example, if the image came from a profiled scanner, you can ask Photoshop to convert the image from the scanner's color space to working RGB. The RGB values in the file will change, but the original color meaning of those values will be faithfully translated into the working RGB space.

Preserving color in legacy images

Photoshop 5.0 will, by default, display and print images differently from previous versions of the application. In other words, if you run Photoshop 4.x and 5.0 side by side, the same image will display and print differently in those two programs.

So what do you do if you have files from previous versions of Photoshop, and you don't want their colors to change when you bring them into Photoshop 5.0? You can ask Photoshop to convert from your old Photoshop Monitor Setup space to the new RGB working space. If you have already been using an ICC monitor profile, you can simply use that as the basis for the conversion. If not, follow these steps.

1. Save your old Monitor Setup as an .AMS file: Launch Photoshop 4.0.x, and then choose Monitor Setup from the Color Settings submenu of the File menu. In the Monitor Setup dialog box, click Save to save the monitor setup information as an .AMS file. Quit Photoshop 4.0.x.
2. Convert your .AMS file to an ICC profile: Launch Photoshop 5.0 and choose RGB Setup from the Color Settings submenu of the File menu. Click Load, navigate to the .AMS file you just saved, select it, and click Open. In the RGB Setup dialog box, click Save to save the old Monitor Setup information as an ICC profile. In Windows 95, save it in the Windows\System\Color directory. In Windows NT, save it in the winnt\system32\Color directory. On the Mac, save it to the ColorSync Profiles subfolder of your System Folder. We suggest naming it something like Legacy Monitor Space.

Now, when you open old Photoshop files, you can ask Photoshop 5.0 to convert them from the legacy monitor space to the new RGB working space. If you want to switch to another RGB working space when you're working with images other than those from previous versions of Photoshop, you can choose one of the

Photoshop 5.0 preset spaces or load a file using the Load button in the RGB Setup dialog box.

Choosing an RGB working space

None of Photoshop 5.0's built-in RGB working spaces are ideal for all color workflows. Furthermore, the default RGB space, sRGB, is very poor for print work. So your first order of business should be to change Photoshop 5.0's default sRGB to something more useful. What makes a good RGB editing space? The desirable properties are as follows:

- It should be perceptually uniform. A gamma of 2.2 is perceptually more uniform than a gamma of 1.8, and devotes more bits of image data to the shadow regions, where they're typically needed in editing. Note: This does not mean that you should calibrate your monitor to a gamma of 2.2. Gamma 1.8 makes a monitor closely mimic the contrast behavior of print, and remains the ideal target gamma for soft proofing (previewing CMYK on screen).
- It should be inherently gray-balanced, so that equal amounts of red, green, and blue always produce a neutral color.
- Its gamut should be large enough to accommodate the input and output devices you intend to use.
- Its gamut should be small enough to avoid wasting bits on colors you can't capture, display, or print.

Note that the last two items represent a trade-off. Too small a gamut means that some colors will be clipped on output. But if you're working with 8-bit-per-channel images, too large a gamut means that the image will be prone to posterization when you edit it, because you're spreading the 256 values those 8 bits represent over such a large gamut that the jump from one value to the next becomes too big.

We're used to considering RGB colors that are outside the CMYK gamut as the main problem, but the CMYK gamut also contains colors that most monitors can't reproduce, particularly in the cyan region. Obviously, when you do an RGB-to-CMYK mode change, the resultant CMYK can't contain any colors that were outside the original source RGB gamut. If your work is destined for print, it's important to choose an RGB working space that covers as much of the CMYK gamut as possible without making it so large that it wastes precious bits on irreproducible colors.

For RGB output to devices like film recorders or those ubiquitous inkjet printers that function like RGB devices, there's the same challenge—you won't be able to reproduce colors that aren't present in the Photoshop RGB working space you used to edit the image. (Most photorealistic inkjet printers have a wider gamut than that of four-color presses.)

So which RGB working space should you use in Photoshop 5.0? It depends on how you'll ultimately output your image (for instance, via the Web or on a CMYK printing press). Here's a rundown of Photoshop's preset RGB working spaces and their various advantages and disadvantages.

sRGB. This color space was designed as an "average PC monitor" RGB space for the World Wide Web, but not many Photoshop users actually edit images with a monitor that would fit this description. (Think $300 15-inch VGA.) sRGB is a useful lowest-common-denominator output space for Web and multimedia images, which will be displayed on monitors of unknown characteristics, but I recommend working in a larger space and converting images to sRGB as a final step.

sRGB is practically useless for any kind of print work. The gamut of sRGB has a serious mismatch with the gamut of CMYK printing; it clips the cyan corner of the print gamut severely. For instance, if you were printing on a typical sheetfed CMYK printer, the closest you can get to a pure, 100 percent cyan in an image edited in the sRGB space is 75 percent cyan, 7 percent magenta, and 5 percent yellow. The sRGB gamut simply doesn't go any further in that direction, so it drastically compromises the reproduction of bright cyans, greens, and blues. The orange-red area is also somewhat subject to clipping, though not as badly.

AppleRGB. This is basically the Photoshop 2.0 default space. It's based on an Apple 13-inch RGB monitor and has a slightly wider gamut than sRGB. However, its 1.8 gamma is not perceptually uniform, so it tends to posterize shadows more quickly than sRGB. It's basically no better than sRGB, though it's somewhat different.

CIE RGB. Developed by the Commission Internationale de l'Éclairage, the same people who gave us CIE Lab, CIE xyY, CIE XYZ, and so on, CIE RGB has a very wide gamut—the primaries are all at the limit of human vision. But that makes it unsuitable for work using 8-bit channels, because posterization will almost inevitably result. It also does a rather poor job of reproducing blue, which goes black very quickly.

CIE RGB may be of interest to users with wide-gamut capture devices that can provide 16-bit files, particularly if they are also going to high-chroma output devices. For 8-bit channels, though, it's simply too large a gamut.

ColorMatch RGB. Based on the Radius Pressview monitor space, ColorMatch RGB could fairly be called the safe choice for print work. It has a reasonably large gamut, though it still clips some of the cyans. Pressview users can use ColorMatch RGB as a working space, and simply open their legacy files with no conversion. If you've been using a high-quality monitor calibrated to D50/gamma1.8, ColorMatch RGB is the closest space to your old Photoshop RGB that Photoshop 5.0 offers.

The only real strikes against it are that it uses a gamma of 1.8, which gives fewer bits in the shadows, and that its gamut is still on the small side.

NTSC (1953). For many years, NTSC (1953) was the standard for broadcast video in North America, and is still in use in some systems. It has a wide gamut and a very yellow white point. The gamut isn't too large for 8-bit work, but when the white-point mismatch is taken into account, posterization becomes a real issue. If you're working on images for broadcast video, NTSC is a rational choice. For other applications, avoid it.

PAL/SECAM. This is the standard for broadcast video in Europe and much of Asia. Its gamut is similar to that of AppleRGB, and is on the small side for print work. Use it if you're doing video for PAL/SECAM systems; otherwise, ignore it.

SMPTE-240M. This is a proposed RGB space for HDTV (high-definition television). If ColorMatch RGB is the safe choice for print work, SMPTE-240M is the aggressive choice for print work. Its gamut comes extremely close to encompassing the CMYK gamut—cyan maxes out at around 98 percent cyan, 2 percent magenta, and 2 percent yellow—and the gamma 2.2 is perceptually uniform.

The downside of SMPTE-240M is that it has a huge excursion into the greens, and hence wastes some bits on colors that you're unlikely to be able to capture, let alone display or reproduce. Nevertheless, it's eminently worth considering, and if you use a 16-bit workflow rather than an 8-bit one, posterization is unlikely to be a problem with the SMPTE-240M space. (SMPTE stands for the Society of Motion Picture and Television Engineers, the body that developed this and other SMPTE standards.)

SMPTE-C. The current U.S. broadcast video-production standard, SMPTE-C has the smallest gamut of all of the spaces being offered, and there's probably no reason to use it unless you're generating images for U.S. video broadcast.

Wide Gamut RGB. This color space is aptly named—the primaries are the pure wavelengths of red, green, and blue light. This space has a huge gamut and will cause 24-bit files to fall apart due to posterization, particularly in the light greens. For the adventurous soul who uses a wide-gamut, 48-bit capture device, it may be a useful tool, but it's totally unsafe for 24-bit work.

Simplified Monitor RGB. Simplified Monitor RGB is basically your monitor ICC profile with any kinks ironed out. You can think of it as the "work like Photoshop 4" option. Unlike all of the other spaces offered, this one isn't device-independent, because it's tied directly to your specific monitor—it will be different on someone else's machine. It has all of the disadvantages of the old color architecture, and none of the benefits of the new one. It may be useful as a source profile for converting legacy images into the RGB working space, or as a transition space as you're trying to get familiar with the new color architecture. But in the long run, it's not the best choice.

Custom RGB spaces

If none of Photoshop 5.0's preset RGB working spaces meet your needs, there's another option—you can define your own RGB working space. (It's actually not that difficult, because an RGB working space is defined by just three primary xy values for red, green, and blue; a white point; and a gamma value.)

You may, for example, want to define a working space whose primaries are the same as those of your scanner or digital camera, thereby ensuring that your working space matches your input device. Or, if the bulk of your work is destined for an RGB output device, you may want to define an RGB space that matches the gamut and gamma of that output device.

Since none of the RGB spaces that Photoshop 5.0 offers are ideal for 24-bit RGB images destined for print—ColorMatch RGB is a tad too small, and SMPTE-240M is a tad too big—I have developed a compromise I call BruceRGB, which is defined as follows:

- **white point = 6500 K**
- **gamma = 2.2**
- **red xy = 0.6400 0.3300**
- **green xy = 0.2800 0.6500**
- **blue xy = 0.1500 0.0600**

I've used this RGB space for several months with good results and am confident that it's a safe alternative for working with 24-bit images that will eventually end up in print, whether from a $500 inkjet printer or from a printing press.

Running the gamut

Photoshop 5.0 offers a very powerful color architecture, but with this power comes responsibility. To get optimal results, you'll need to choose an appropriate RGB working space, and you may need to experiment to find the settings that are ideal for your work. You'll be glad that you did, though—investing a little time and effort in this crucial area will ensure that your images look beautiful and save you hours of frustration "chasing color" in the future. ◆

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