The role of working spaces in Adobe applications

Understanding the role and appropriate use of RGB working spaces is necessary if you are using Adobe® Photoshop®, Adobe Camera Raw, or any application that supports International Color Consortium (ICC) color management. This white paper discusses what RGB working spaces are, why they are beneficial, and when you might select one working space over another. First, some basic imaging and color theory.

It's all a numbers game

A digital image is essentially a huge collection of numbers. Color management is necessary because numbers alone do not fully describe the appearance of color; they are only a partial ingredient list for mixing them. Photoshop treats a document filled with a single, solid color and a beautiful photographic image the same. While a photograph might contain millions of tiny, solid-colored pixels, it is necessary to assign a numeric value to each.

Imagine a single, solid color displayed in Photoshop. Let's use Red 248/Green 28/Blue 120 as an example. What color do these numbers represent and how should it appear on a specific output device like a display or a printer? You can expect this group of numbers to produce a color that appears as some shade of red, as the red value is much higher than the green or blue values. Unfortunately, these numbers alone don't tell you how red this color will reproduce, or if it will produce the red you expect. You need more information than a set of numbers to define a color.

Defining a color model and color space provides the additional, necessary information. There are subtle but important differences between a color model and a color space, so let's look at each.

Color models

Photoshop supports several color models. A color model is a grouping of numeric values based on different primary colors (colors used to create other colors). One such color model is RGB (red, green, blue), which uses additive primary colors: colors created using red, green, and blue light. Adding certain proportions of each primary color can simulate a huge number of colors. When the maximum value of all three primary colors is produced, the result is white.

Another color model is CMY (cyan, magenta, yellow). The primary colors are subtractive; cyan, magenta, and yellow values subtract one of the additive primaries from white light. Adding a maximum of all the values produces—in theory—black. Since these pigments are quite impure, it is often necessary to work with a CMYK (cyan, magenta, yellow, black) color model, in which K (black) pigment is used to produce color on a printed page. Yet another color model is grayscale.

There is a particular problem with RGB, CMYK, and grayscale color models. These models are based on the behavior of devices. The devices that produce color using additive primaries (light) in the case of RGB or subtractive primaries (pigments or dyes) in the case of CMYK, all behave differently. The actual scale of the RGB, primaries can differ from device to device, just as various pigments from different manufacturers produce dissimilar results. For this reason, RGB and CMYK color models are known as *device dependent*. The same set of numbers can produce a different color appearance depending on the device. You've probably witnessed this effect in an electronics store where a dozen TVs, all turned to the same channel, produce different color. While each TV receives the same set of RGB numbers, they all produce different colors using those numbers. The RGB and CMYK colors aren't enough: To accurately reproduce color, it's also necessary to understand how humans perceive color.

L*a*b*, x,y,Y, and CIE XYZ, define and encompass all human vision. The primary colors are theoretical, mathematically constructed values. For example, instead of using RGB to define three primaries, scientists used xyY. Using these three mathematical primaries, it is possible to define color in much the same way as using RGB or CMY primaries. There is one important difference. These color models have a fully defined scale, based on how humans see color; therefore, a particular set of xyY values always defines the same color appearance. These color models are known as device independent. Since the theoretical primaries are based on human vision, the numbers in such a color space define colors as you see them, rather than basing them on dissimilar devices like a digital camera, scanner, display, or printer. In a device independent color space, the "device" if you will, is you and me.

Color spaces

Having only an RGB value such as R248/G28/B120 does not tell us how to reproduce that color on any specific device. The values are only a ratio of the primary RGB components without a necessary scale. You can see the numeric ratio contains more red than green, and more blue than green, but without knowing the scale of the RGB primaries in relationship to human vision, you can't reproduce this color as expected. Therefore, a color space further defines the color model by providing the scale of the primary colors and all resulting colors within a portion of human vision.

In Figure 1, you see that one advantage of using numbers to define color is that it is possible to graph a color space, in this case two-dimensionally. This horseshoe-shaped plot represents all the colors humans can see. This plot is called the CIE x,y Chromaticity Diagram. The colors running the circumference of this plot represent the pure spectrum of visible light. As colors move inward, they become less saturated. You can plot a numeric value based on x and y coordinates anywhere within this color space to define its scale within human vision**. Note that all color spaces are three-dimensional. You only see the mapping of hue and saturation represented by x and y values. The third dimension, specified by a capital Y, describes the luminance of the color space: the range from light to dark.

***Note:** For those aspiring color geeks: The x and y values used to plot a color on this diagram are referred to as the chromaticity coordinates, or sometimes, chromaticity values.*
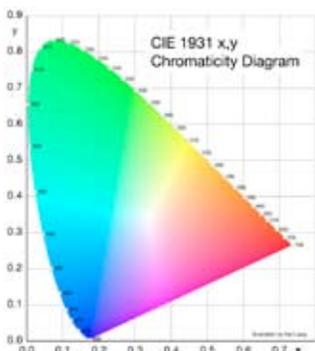

Figure 1. The horseshoe-shaped plot (CIE x,y Chromaticity Diagram), represents the gamut of human vision. The numbers around the circumference represent the pure spectral colors (Red–Orange–Yellow–Green–Blue–Indigo–Violet) of visible light, which range from approximately 400nm to 700nm. As the colors move inward, they are less saturated.

Figure 2 illustrates the defined scale of the primaries for a color space called sRGB. You can see where the three primaries, red, green, and blue, fit within the color space of human vision. Note that the most saturated green you can numerically define using 8-bit color is R0/G255/B0. The green dot in Figure 2 represents that color number within the sRGB color space as well as within human vision.
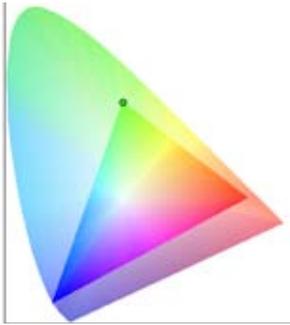
Figure 2. In a similar color plot, the sRGB color space is grafted over the CIE x,y Chromaticity Diagram. The red, green, and blue primaries form the simple triangular shape. The green dot represents the most saturated green (R0/G255/B0).

Now look at Figure 3, which is a plot of the RGB primaries of another color space called Adobe RGB (1998). The green dot is also numerically defined as R0/G255/B0, yet you can see that it appears in a different location within human vision. The most saturated, primary green in Adobe RGB (1998) has a different scale than the most saturated green in sRGB. This difference illustrates why it is necessary to define both a color space and a set of color numbers. One without the other doesn't provide enough information. The two RGB color spaces we just discussed produce different colors of green, yet use the same numbers, so it is critical that all images have an associated color space so the numbers have a defined scale within human vision.
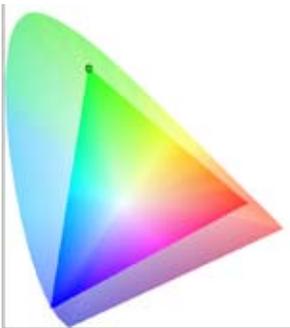
Figure 3. Here Adobe RGB (1998) is plotted. Notice that the red, green, and blue primaries are father apart than those seen in Figure 2. Since they move farther out from the center, closer to the maximum saturation of human vision, it is fair to say the color gamut is larger than sRGB.

The ability to plot any color space within human vision defines a range of color and tone, which is called the color gamut. You can see in Figures 2 and 3 that the color gamut of sRGB is smaller than that of Adobe RGB (1998), while the gamut of human vision is much larger. When discussing working spaces, color gamut plays an important role in their selection. It is important to understand that a color space supplies the information a computer needs to properly display and output all color using the only language it understands: sets of numbers.

One way to associate a color space to a color document is by embedding the document with an ICC profile. The task of these profiles is to define the color space for the numbers contained within each document. This definition is necessary for Photoshop and other ICC-aware applications to both properly preview and output color. As soon as Photoshop associates R0/G255/B0 with sRGB, it can properly preview and handle those numbers. Treating R0/G255/B0 as Adobe RGB (1998) or any other color space provides the incorrect definition and this green color would not reproduce as expected.

You can test this phenomenon yourself. Open Ducky.tif, which is in the Samples folder within the Photoshop application folder on the hard disk. This image is in the sRGB color space. Now,

choose Edit > Assign Profile. From the Profile pop-up menu, choose other RGB color space profiles and notice that as you do so, the color appearance changes. If you place your cursor over a part of the image and select different color spaces, you will see the underlying numbers do not change in the Photoshop Info palette. The color appearance changes because Photoshop is being told those numbers are in a different scale–a different color space. It then updates the preview accordingly.

Classes of color spaces

There are various classes of color spaces, which should be defined before I move on. There are color spaces that define the behavior of a capture device like a scanner or digital camera. These devices all use an RGB color model. There are color spaces that define how an output device like a printer reproduces color. Depending on the printer, these color spaces may be RGB, grayscale, CMY, or CMYK. There is also a class of color spaces that are ideal for editing an image, such as the RGB working space. Another name for an RGB working space could be "RGB editing space." Why is a class of editing color spaces necessary? Prior to Photoshop 5.0, all color numbers in a document were sent directly to the display. When you viewed these images, the color space was based on the unique behavior of your display and how it reproduced color. The problem was that virtually every display behaves differently. It was likely that a document that appeared one way on my monitor would appear differently on your monitor.

When identical color numbers produced dissimilar color appearance on different hardware, many problems resulted. Which color appearance was correct? To solve this issue, two steps were necessary. First, documents would be converted into a standardized color space for editing rather than the multitude of color spaces based on a display. This conversion from the original color space into an RGB working space is a process known as encoding. This process alone didn't address the fact that each display continued to produce a unique behavior. Therefore, the next step was to calibrate and profile each display to define the behavior. Photoshop would then use the ICC display profile to compensate for how it previewed these color numbers. The result: identical color numbers produced identical color appearances on different hardware!

Design and benefits of RGB workspaces

Photoshop provides a number of synthetic RGB color working spaces. While some of these working spaces are based on specifications of existing devices, none are constructed to define any individual device. An example is sRGB, a theoretical color space derived from HDTV standards. These precise specifications define such parameters as the ambient light surrounding this hypothetical display. The actual device behaviors of displays are often dissimilar to such specifications. Plus, you can't depend upon any two devices behaving identically. Further, many devices change behavior as they age, so you should not assume they fall into this precise sRGB description. A display system has specific idiosyncrasies and has a fixed gamut size that further produces limitations when used to define a document's color.

Synthetic color spaces do not have to suffer any of these limitations. These RGB working spaces are mathematically constructed to provide a color space that provides useful and flexible editing qualities. For example, one benefit of synthetically constructed RGB working spaces is that it is easy to define a neutral color. When each value of red, green and blue is equal anywhere within the entire color space, that color is neutral. This benefit is not necessarily the case with color spaces based on actual devices like a scanner, digital camera, and certainly not a printer. In a synthetic RGB working space, you are assured that a color is neutral gray when all three values are equal. For example, R5/G5/B5 as well as R200/G200/B200, or any identical set of RGB numbers defines a neutral color. This behavior is one reason RGB working spaces are often referred to as "well behaved," and makes it easy to use the various set-neutral eyedroppers in Photoshop and Camera Raw when you wish to ensure images have no colorcast.

RGB working spaces, what are the differences?

Adobe includes a number of RGB working spaces for Photoshop, Camera Raw, and other components in Adobe Create Suite 2. Let's examine the differences before discussing which might be more appropriate for your editing tasks.

There are two primary attributes of these synthetic RGB working spaces to consider. Clearly the most important is the gamut of the color space. As discussed, the scale of the RGB primaries can differ within the gamut of human vision. The gamut of these RGB working spaces ranges from small to very large. As you will see, the size of the working space gamut can play a profound role in how you edit and eventually output your images.

The other attribute is called the gamma encoding of the working space. This gamma encoding has no relationship to the gamma of your display! Rather, this gamma value defines how edits applied to an image are spread over its entire tonal range. As you edit an image using 2.2 gamma encoding, corrections appear to produce the same degree of change in shadows, highlights, and midtones. This behavior is known as perceptually uniform, an advantage of synthetic color spaces that are rarely achievable in other color spaces.

Recognizing the attributes of gamut and gamma encoding, let's take a closer look at the RGB working spaces installed with Adobe applications.

sRGB

Hewlett-Packard and Microsoft designed sRGB as a standardized RGB space for consumer-level digital cameras, scanners, and printers. The goal was that users of these devices wouldn't require any color management knowledge to produce acceptable results. Such devices would assume the color space is sRGB, making the reproduction process within applications that didn't use color management simple.

sRGB is derived from HDTV standards, so nearly all CRT and LCD displays can reasonably produce sRGB if properly calibrated. Even uncalibrated, such devices often produce adequate color from images in sRGB.

Since few web browsers are ICC aware, sRGB is currently an ideal color space for images destined for the Internet. Of all the RGB working spaces installed with Adobe applications, sRGB has the smallest gamut. The gamma encoding is 2.2. However, sRGB's gamut is a limitation for more demanding output, such as a printing press or many of the ink jet and photo printers so commonly used today.

Apple RGB

Apple RGB is a legacy working space based on the original Apple 13" Trinitron monitor. The gamut isn't much larger than sRGB and the gamma encoding is 1.8. Early users of Macintosh® computers working with products such as Photoshop and Adobe® Illustrator® used Apple RGB as their working space prior to the introduction of additional working spaces in these products. Unless you need to work with documents created from very old versions of Photoshop (4.0 or earlier), there is little reason to consider Apple RGB.

ColorMatch RGB

Years before ICC color management was available in Photoshop, a company named Radius produced a high-end, calibrated display called the PressView. When calibrated, the PressView produced a condition known as ColorMatch RGB that was the specific and exacting color space all PressView displays achieved; their RGB working space! The gamut of ColorMatch RGB is slightly larger than both sRGB and Apple RGB and uses a 1.8 gamma encoding. ColorMatch RGB is a useful working space for those who may have created and edited documents on such a display. For example, if I open an untagged image I created years ago on my PressView and assign ColorMatch RGB, the color appearance exactly matches what I was seeing when I originally created this image.

Adobe RGB (1998)

This working space has a significantly larger gamut than any of the working spaces discussed so far. Adobe RGB (1998) uses 2.2 gamma encoding. This working space is much better for those who will output their files to a printing press, since the gamut allows all colors in Specifications for Web Offset Publications (SWOP) CMYK to be fully contained. One issue with a gamut this large is it is larger than the gamut of nearly all displays. Saturated colors that may exist in Adobe RGB (1998) could be outside the display gamut and thus not visible. You might be editing colors you can't see. This fact is true of all working spaces that exceed a display gamut. Note that a few high-end displays providing an extended gamut matching Adobe RGB are now available, but at a very high price. Unless you know you have such a display, you are probably working within the gamut restrictions of sRGB when viewing your images. The advantages and disadvantages of wide gamut spaces are below in more detail.

Wide Gamut RGB

As the name implies, Wide Gamut RGB is a significantly larger gamut working space than any yet discussed. This color space uses 2.2 gamma encoding and can contain a large number of colors that can't be printed on most output devices with perhaps the exception of a film recorder; a device used to reproduce images on conventional film. Like Adobe RGB, Wide Gamut RGB can define many colors that can't be displayed on your monitor.

ProPhoto RGB

Originally named ROMM RGB and designed by Eastman Kodak, this working space was later renamed ProPhoto RGB. The gamma encoding is 1.8. ProPhoto RGB is an extremely large gamut working space, to the degree that the blue primary falls outside the gamut the CIE x,y Chromaticity Diagram. This behavior is possible using a synthetic color space since the blue primary is defined mathematically. For such a large gamut working space, Pro Photo RGB has proven over the years to work very well despite the display limitations discussed.

There are a number of other synthetic RGB working spaces available that are not installed with Adobe applications. There have been several well-known color geeks who have built their own working spaces based on specific needs; for example, Bruce RGB, Don RGB, and LStar-Beta-RGB, to name a few. Unless you have a compelling reason to try these working spaces, my advice would be to concentrate on the RGB workspaces supported by Adobe applications. However, I wanted you to know there are other, custom-designed RGB working spaces floating around the Internet which can be installed and used in many ICC-aware applications.

Limitations of working spaces

As discussed, the gamut of a working space in comparison with the gamut of your display should be considered. However, just because a working space gamut exceeds the display gamut doesn't mean a color document will exceed the gamut of either. Images have a color gamut as well. You might photograph a scene of very pastel colors such as a white dog on snow. You could encode that image into ProPhoto RGB, but a huge portion of that working space gamut isn't used. The scene gamut might fit better in Adobe RGB (1998) or even sRGB. You need to be aware of the working space gamut, the scene gamut, as well as the gamut of any output device you may use.

When you work with 24-bit images, all color and tone is defined in three 8-bit color channels. When you work with wide gamut working spaces, the same bits need to be spread farther apart over the entire color space. Consider this spreading of a finite number of bits as follows: Imagine you have a half-inflated balloon that has 16.7 million dots evenly spaced over its surface. Now you blow up the balloon to twice its original size. Each dot is spread farther apart. When you work with 8-bit-per-channel files, you create this effect when you encode the bits into a progressively larger gamut working spaces. In such situations, it is possible that editing images will produce banding (aliasing). For this reason, should you decide to use a wide gamut working space—for example, something wider than Adobe RGB (1998)—you should attempt to encode the data in 16-bit color. Many capture devices produce more than 8-bits per color and allow you to retain this extra data to use in Photoshop. While the file size will be twice as big and image processing will take longer, you can't be too careful with your data. You may also wish to use 16-bit data with smaller gamut color spaces.

There are no perfect RGB working spaces

In a perfect world, there would be only one RGB working space that was ideal for all uses. An ideal RGB working space would be one that could fully contain all the colors from your capture device or the gamut of the scene, and the gamut of all your output devices. Let's assume the gamut of the capture device or the scene gamut is larger than the gamut of the working space. Upon conversion and encoding, all the colors outside the captured working space would be clipped (lost). Let's also assume the gamut of the output color space is larger than this working space. The colors clipped might have fallen within gamut of the output device but are now unavailable. You lost the opportunity to reproduce certain colors and tones that were originally within the image.

It is not always easy to determine the gamut of an output device you might use today or in the future. The history of digital imaging proves that wider gamut printing technology becomes available on a regular basis. This fact is especially true with ink jet technology. Today it is possible to use inks that reproduce colors outside the gamut of Adobe RGB (1998). Using a significantly larger gamut working space than the image or output device provides no benefit, but at least you have all the original colors at your disposal. An RGB working space gamut should ideally be large enough to contain all the colors you hope to reproduce.

Another issue in selecting the appropriate gamut working space is the significant mismatch in size and shape between synthetic RGB working spaces and output color spaces. It is necessary to examine such color spaces using 3D gamut projections because color spaces are three-dimensional. This issue is easy to illustrate on a computer with the right tools, but a bit more difficult to illustrate on a printed page. The following figures should give you some idea of what I'm talking about. The next series of illustrations were produced using a product called ColorThink from Chromix. One or more ICC profiles can be loaded and rotated three-dimensionally to fully show how the color gamut differs.

In Figure 4, you can see the gamut plot of sRGB and Adobe RGB (1998) together. Adobe RGB (1998) is displayed in ColorThink set to "true colors," which plots the actual colors within this color space. The opacity of Adobe RGB (1998) has been reduced so you can see the sRGB gamut, which fits fully inside Adobe RGB (1998). The sRGB gamut is illustrated using a wireframe so it is easier to see it in comparison to Adobe RGB (1998). Note that the "true colors" in sRGB would line up with Adobe RGB (1998), but the scale of the saturated colors falls in a different location within human vision. Notice in this illustration the simple triangular outline, which represents the location of the RGB primaries of each space. This triangular plot appears much the same in Figures 2 and 3, above.
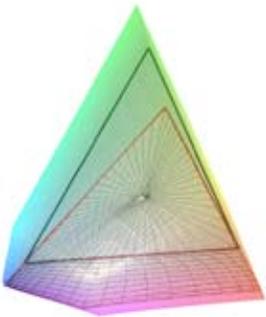
Figure 4. Removing the CIE x,y Chromaticity Diagram, this illustration shows the gamut of sRGB and Adobe RGB (1998). To make it easier to compare the two, I've set sRGB to be mapped as a wireframe and lowered the opacity of Adobe RGB (1998). **Click here to view 3D representation of this color space.**

In Figure 5 you can see the gamut plot of sRGB and an Epson 2400 ink jet printer superimposed in the same location as Figure 4. From this view, it appears there are colors within sRGB that are outside the gamut of the Epson 2400. This difference might give you the impression that sRGB has a larger color gamut. That impresion is true in this location of the color space. However, this single view doesn't fully illustrate the gamut of both spaces. By rotating the spaces three-dimensionally, you can now see there are many colors (yellows and greens) that fall far outside sRGB. If you used sRGB as a working space, you would not be able to output the more saturated greens and yellows this printer is capable of reproducing.
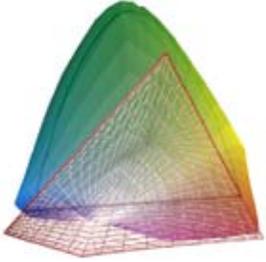
Figure 5. Here I've removed Adobe RGB (1998) and replaced it with the gamut plot of an Epson 2400. Notice that there are areas of sRGB that fall outside this printer's gamut. In this view you can see many shades of green and yellow that fall outside the gamut of sRGB. **Click here to view a 3D representation of this color space.**
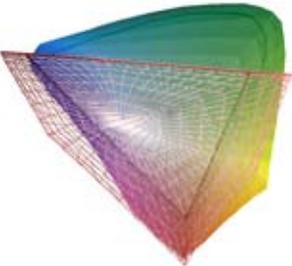

Figure 6. The same two profiles as Figure 5, but I've rotated them three-dimensionally so you can see another angle. Here again you can see a significant number of greens and yellows the Epson can reproduce that fall far outside the gamut of sRGB. Also notice the different gamut shape of an output color space compared to the simple gamut shape of an RGB working space.
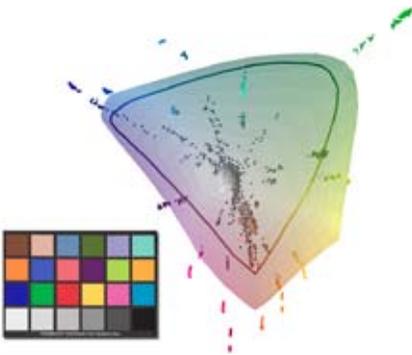

Figure 7. I've loaded an image of a Macbeth color checker, shot on my digital camera. The gamut of this image is represented by colored dots. Notice that some saturated reds, blues, greens and yellows in the image fall outside the gamut of the Epson. The actual image is inserted to the left of this gamut plot.

Do images exist that can contain colors such as those plotted in the images above? Absolutely. In Figure 7, I have plotted the gamut of an image in ColorThink. I hid the wireframe of sRGB to make the gamut easier to view. The gamut of this image is represented by colored dots, some of which fall outside the gamut of my Epson 2400. Figure 8 below shows the sRGB wireframe so you can see the gamut of the image, the Epson, and sRGB. Notice that there are saturated yellows, reds, and blues in the image that fall outside the gamut both sRGB and the Epson 2400. In Figure 9, I've turned on the gamut plot of Adobe RGB (1998). More of the image gamut falls within Adobe RGB (1998) than sRGB, yet some colors still fall outside the gamut of the Epson 2400.

Note that you are only viewing one portion of the 3D gamut! By spinning these color spaces in other directions, it is possible to see additional colors and tones that fall in differing positions within the gamut of human vision. While the total volume of sRGB, or for that matter Adobe RGB (1998), appears larger than the Epson, those colors that fall outside the gamut of these spaces are important to recognize. Some people who have written about the gamut of working spaces have said there are no printers with a color space that is larger (holding more volume of data) than sRGB. By simply looking at the total volume, they ignore the more important fact that there are colors that exceed the gamut of these working spaces. Those very colors cannot be reproduced on many output devices. The illustrations below clarify the differences between the gamut of working spaces, images, and printers and those colors you might be able capture, edit, and reproduce.
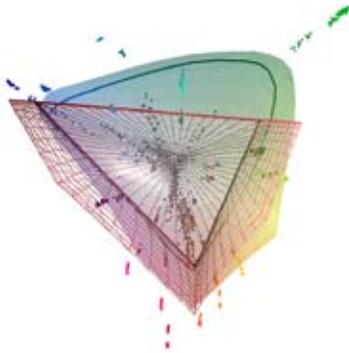

Figure 8. This image is the same view as Figure 7, but I've now turned on the sRGB gamut, represented in a wireframe, so you can see how far out of gamut the image is from this working space.
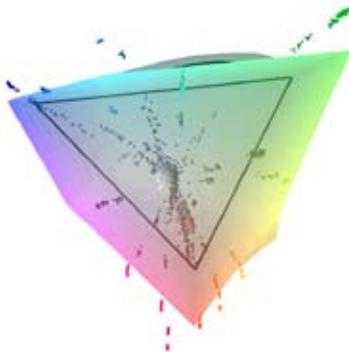

Figure 9. Here the gamut of Adobe RGB (1998) is seen instead of the gamut of sRGB. In this illustration, I have left the plot of Adobe RGB (1998) as "true colors" and lowered the opacity so you can still view the dots, which represent the gamut of the image seen in Figure 7. Even Adobe RGB (1998) isn't large enough to fully contain all the colors from this image.

There is one additional consideration with respect to very wide gamut working spaces in relationship to output color spaces. There is almost always a significant mismatch between the overall shapes of simple RGB working spaces compared to the more complex shapes of output color spaces. Think of this mismatch between the two color spaces as trying to fit a square peg in a round hole. In order to accommodate the square peg, the round hole has to be much larger in diameter than it otherwise would be. Once the square peg is fully inserted into this large, round hole, there remains a good deal of empty space. The extra area might seem like a waste, yet it is necessary to make such a fit.

It is often necessary to define a very large gamut RGB working space with a great deal of distance between the primaries to fit a smaller, but dissimilarly shaped, output space. ProPhoto RGB has a very large gamut by design, and while many of the defined colors can neither be seen nor reproduced, the overall size (the round hole) is necessary to contain colors that will be converted to an output space (the square peg).

Working space selections in Photoshop

You are expected to select an RGB working space in the Photoshop Color Settings dialog box as well as a color space for CMYK and grayscale files (See Figure 10). Depending on the color policies** and configuration of the Profile Mismatches warning option, the color space you select may play a minor role. For example, should you select Adobe RGB (1998) as the "preferred" working space, you can open an RGB document in any additional color space and Photoshop warns you of the mismatch if you have selected Profile Mismatches: Ask When Opening in the Color Settings dialog box. Photoshop displays a dialog box informing you that the document isn't in Adobe RGB (1998). You can decide to open the document in the original working space (preserve) or convert the document into Adobe RGB (1998). In most cases, you'll want to preserve the original color space. Photoshop is simply letting you know that the document's color space doesn't match the preferred working space you set in the color settings.

One area in which the preferred working space plays an important role is when you open an untagged document. Photoshop can't properly preview an image unless it knows the color space. You saw the effect of using differing color spaces on the Ducky.tif image. An untagged document has no embedded profile; therefore Photoshop has to make assumptions about the scale of the document's numbers (the color space). Photoshop uses the color space you selected as the working space in the Color Settings dialog box. Should that be Adobe RGB (1998), Photoshop assumes all untagged RGB documents are in this color space even if they aren't. This example illustrates why untagged documents in any color model are very problematic. You should always embed the correct ICC profile that defines the color space, in all your documents.

One other important rule when you select your preferred RGB working space: Never select a display profile. This highly device-dependent color space defeats the purpose of using a well-behaved synthetic working space. While some synthetic RGB working spaces are based on the behavior of a display, it is important to recognize that a working space isn't a monitor color space (or vice versa).

** For more information about the role of Photoshop's color policy, see Color Management for Photographers, at www.digitaldog.net/files/Color_Policy_Tutorial.pdf
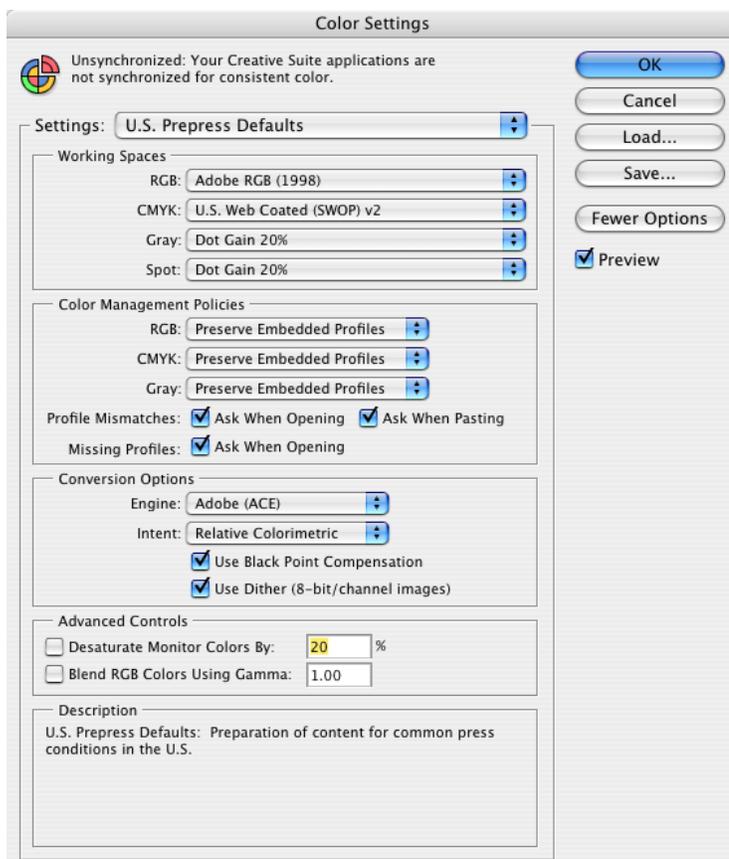

Figure 10. The Color Settings dialog box in Photoshop with the Profile Mismatches options selected.

Working space selections in Camera Raw

When you process RAW files from a digital camera, there are two distinct operations that take place. The first is called rendering. Rendering is the process of altering the various controls and sliders in Camera Raw to produce a pleasing image. The second operation is called encoding. Encoding is the step whereby the rendered data is converted into a selected color space. Camera Raw allows you to view the scene gamut based upon useful feedback in its histogram, which updates as you select one of the four supported RGB working spaces: sRGB, ColorMatch RGB, Adobe RGB (1998), or ProPhoto RGB. Most users familiar with a histogram recognize how it can show highlight or shadow clipping. If you see a white spike on either end of the histogram, either a shadow or highlight is clipped. The histogram in Camera Raw can also show saturation clipping, which can indicate if the scene data is out of gamut based on the current rendering and encoding. Suppose you see a red spike on one end of the histogram as seen in Figure 10. This spike indicates the red channel is clipped based on the current working space. You could lower the Saturation slider to alter the rendering of the image, but you might like the color appearance and instead try a wider gamut working space in an attempt to encode that saturated color.

In Figure 11 you can see an image captured on a Canon 350D of Sydney Harbor. While it doesn't appear to be an overly saturated scene, notice how the histogram in Camera Raw updates as I toggle from sRGB to Adobe RGB (1998) and finally to ProPhoto RGB. If I like the color rendering and want to fully contain all the colors, I need to encode the data in ProPhoto RGB. I will do so in 16-bit because of the very wide gamut of ProPhoto RGB.
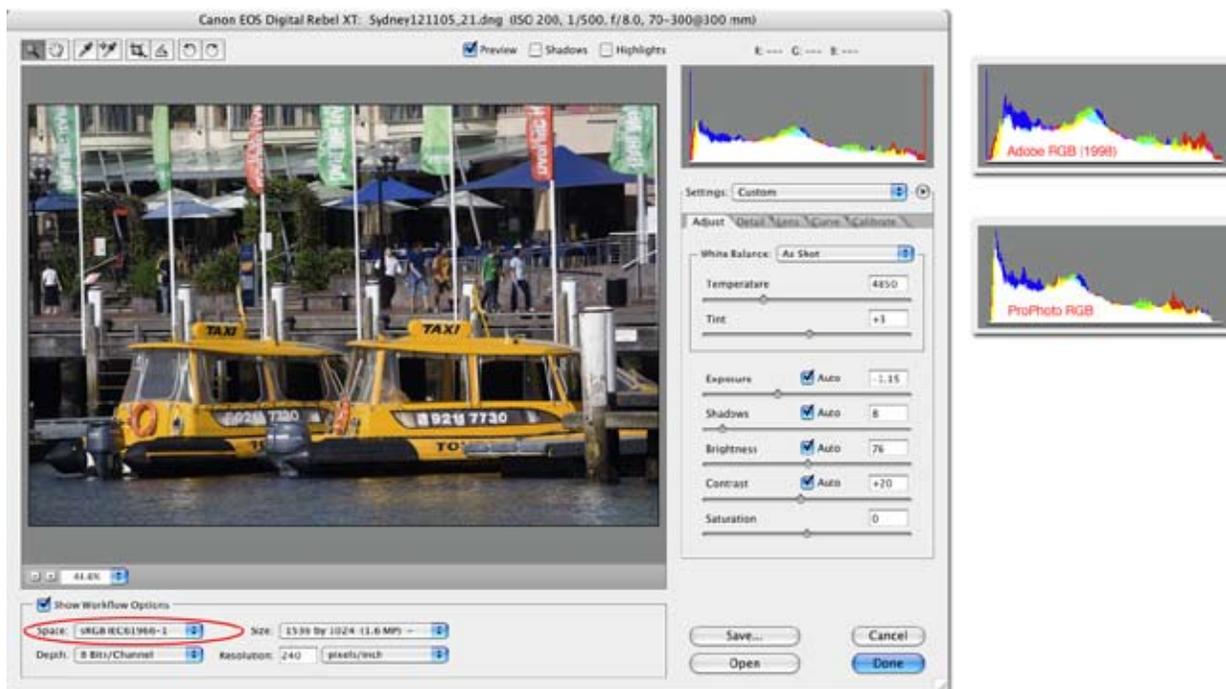

Figure 11. This image has a gamut that clips when encoded in sRGB as seen in the Camera Raw histogram. There is a blue spike on the left side and a red spike on the right (left). I then toggle the encoding to Adobe RGB (1998) and the histogram is represented to the right of the Camera Raw interface. The blue spike remains (top right). Notice the histogram below the one encoded in Adobe RGB (1998). Here I've selected ProPhoto RGB and the entire scene gamut is fully contained, there are no color spikes (bottom right).

Now, look at the image in Figure 12. This image is a very muted scene and when the encoding is set to sRGB, I have no clipping in the histogram. There is no benefit in using a wider gamut color space encoding, so I will select sRGB in Camera Raw. While my printer has a wider gamut, the scene gamut is rather small. Unless I plan to paste this image into a wider gamut scene, perhaps making a composite, I'll select a color space encoding that more closely fits the gamut of the scene data.
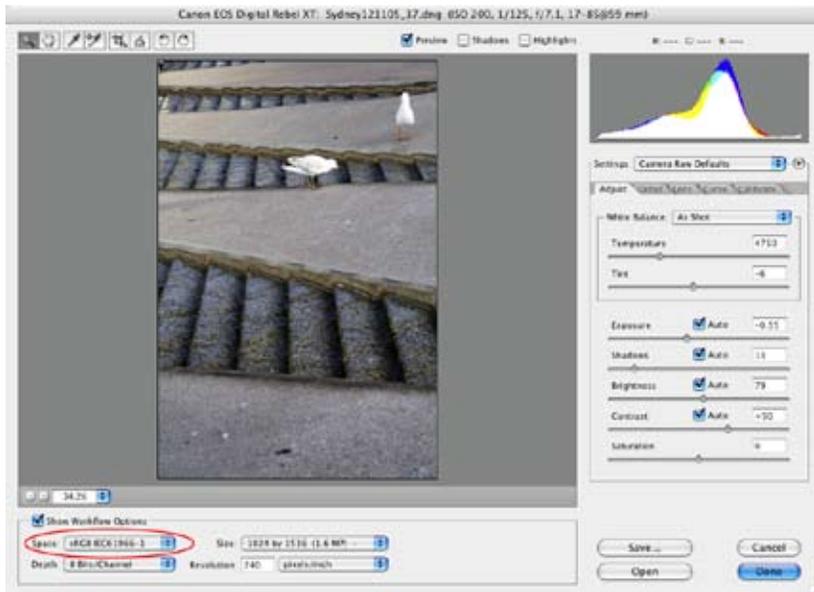

Figure 12. This muted scene fits fully in the sRGB gamut; there are no spikes in the histogram.

Conclusions

As you've seen, selecting a working space is based on several parameters. Understand that while using a working space that might clip some colors or sending a smaller gamut image to a wider gamut printer may not utilize all the colors possible, using sound color management will still produce acceptable prints. You will not use all the colors you captured or could have reproduced.

If your goal is to use all the colors you can capture when you output your files, the role of the working space is important. However, it should be clear that a very large gamut working space isn't automatically the best option for all situations or something you can "set and forget."

ABOUT THE AUTHOR

Andrew Rodney is owner of The Digital Dog, a digital imaging training and consulting business located in Santa Fe, New Mexico. Andrew has been a beta tester, for Photoshop since version 2.5. Andrew writes a regular column on color management for Professional Photographer magazine. He specializes in color management solutions and training and is the author of "Color Management for Photographers, Hands on Techniques for Photoshop Users" published by Focal Press. Andrew is one of the principle partners of Pixel Genius LLC, a company that has created such products as PhotoKit and PhotoKit-Sharpener (www.pixelgenius.com/index.html). For more information about Andrew, visit his webiste at www.digitaldog.net/.

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