Color Numbers and Color Gamut.

Does *Adobe RGB (1998)* have more colors than *sRGB?* It's the wrong question but no it doesn't. But to uncover why, we have to look at a few facts about color spaces, specifically RGB working spaces like sRGB, Adobe RGB (1998), *ProPhoto RGB*.

Adobe RGB (1998) and sRGB, ProPhoto RGB are just color spaces, containers. They don't inherently have any information other than specifications for primaries, white point, and gamma. Until we actually have a pixel, they don't contain any information. The pixel has what is called an encoding which can provide a number of possible *device values*. For example, 24 bit color, (three channels, 8-bit each) can mathematically define 16.7 million device values. Can we see 16.7 million colors? No. Far less. Depending on who's figures you examine, the range is said to be "more than 100,000 to 10 million". The number is up to debate but the point is, we can use math to produce a value that has no actual relationship to what we can see. All the RGB working spaces have exactly the same number of addressable device values and the total number is set by the bit depth of the image file used for encoding, i.e., 8-bit, 16-bit.

Before we can define a number of colors, we have to define: What is color? Color isn't a wavelength or property of light. Color, is a perceptual property, something that occurs deep inside our brains. So if you can't see it, it's not a color. As such, colors are defined based on perceptual experiments. Color is not a particular wavelength of light, It is a cognitive perception. Another term is *Color Value,* which refer to human perception and specifically to colorimetry. Lab, Luv, XYZ, Yxy, etc are all color values. We can use math and a metric called deltaE to define when one set of color values which are imperceptible (indistinguishable) from another set of numbers (color values). delta-E refers to differences in color values. For sake of argument, let's say in one color space, sRGB, it isn't possible to see a difference between 2/255/240 and 1/255/240 as they have the same Lab values (90/-54/-8). As such, we can't count that example as being two colors, we can't see any difference between them, they look identical. A deltaE of less than 1 between two color values is said to be imperceptible but to complicate matters, there are several formulas for calculating this metric. Further the ability of the eye distinguish two colors as different and is more limited for yellows but is better for greens and blues. This just adds even more difficulty in assigning a meaningful and accurate number of colors to these colors spaces.

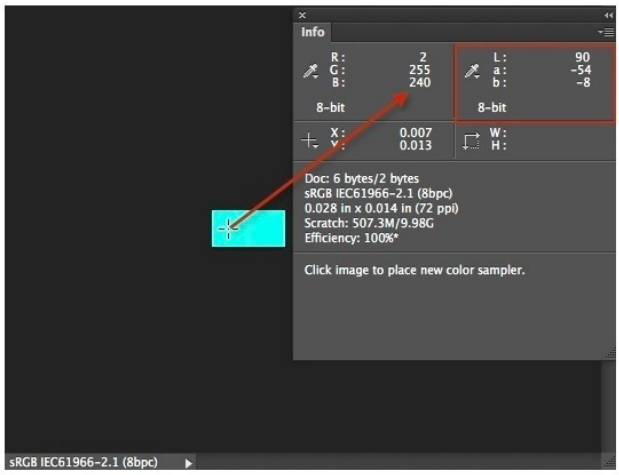
Now we have to look at color spaces like ProPhoto RGB. If you examine a plot of this synthetic color space on top of the gamut of human vision (the CIE chromaticity diagram), part of it falls outside the plot. It can define device values, numbers, which represent "colors" we can't see. So these "*imagery colors*" can't be counted when we ask, does ProPhoto RGB have more colors than sRGB or another color space. One of the best explanations of why it is folly to even attempt to put a number (of colors) on top of a color space comes from Graeme Gill the creator of the Argyll Color Management System: "*Colorspaces are conceptually continuous, not discrete, therefore it's wrong to talk about number of colors*". Just examining ProPhoto RGB further illustrates it is impossible to define the number of colors it can contain as it can defines *color values* that we can't see as colors. Parts of ProPhoto RGB's gamut lies outside human vision!

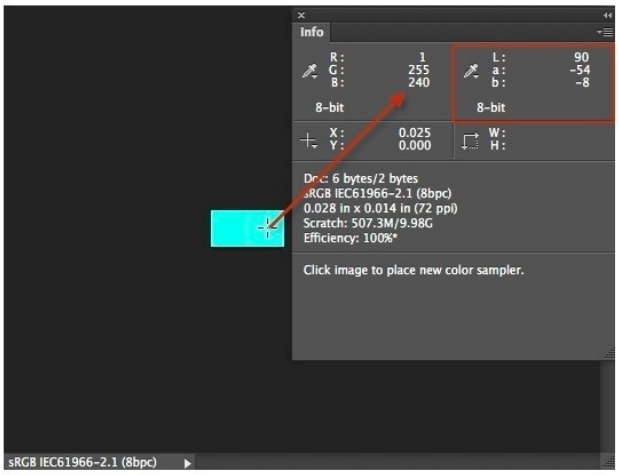
Much like 24 bit color can define more device values than colors we can see. Encoding is however a useful attribute when editing our images so the point isn't to dismiss it but rather point out, it provides values for something that isn't a color, it's just a number, a device value. As an analogy, if you were to purchase a ruler to measure something, it is possible the tiny lines that divide up the unit of measure could be finer than you can see. What would be the point of giving you a 1 foot long ruler where the individual lines that defined the distance between each was a micron apart instead of a 1/16 of an inch? The micron unit is valid. You just can't see it or use it with your naked eye to measure anything. Think of the encoding of a pixel value the same way with respect to color expect unlike a micron that does exist, a device value defining a color you can't see doesn't exist; it's not a color.

The difference in color gamuts is their **range** and the **scale** of colors, not the number of colors values. This confuses many people because they see a larger gamut plot, a larger volume, and assume larger means more colors. But one has nothing to do with the other. ProPhoto RGB covers a larger range of chroma (what some call *Saturation*) than Adobe RGB (1998). Adobe RGB (1998) covers a larger range of chroma than sRGB. This has nothing to do with the number of device values, that's an attribute of how we encode the pixel values. And we can use finer ways to divide up this data. For example, in 16-bit color, the math allows us to define billion's of color values, but that doesn't change the fact we still can't see 16.7 million colors in the 24 bit encoding of these pixels. As such, it's best to talk about encoding having a potential to define millions or billions of numbers, device values, that *could* be associated to a color value thus color, **if** we could see them. But if we can't differentiae them visibly, it is silly to suggest they are indeed colors. Don't confuse a color number, a device value, for a color, a color you can see!

Color numbers may not be Color!

- In sRGB, two pixels with different RGB device values have the same Lab values. They ARE the same color!
- This is how we can define 16.7 million device color values but not 16.7 million colors: We can't see that many colors.





2/255/240 and 1/255/240 are the same color! Notice the L*a*b* values which are based on human color perception. Color, is a perceptual property, something that occurs deep inside our brains. So if you can't see it, it's not a color.