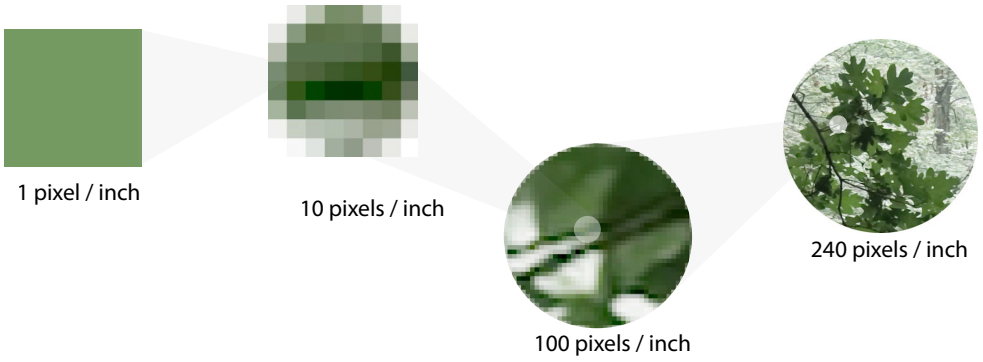
Imaging Principles: Color Models, Pixels, Channels, and Image Depth

Color Models

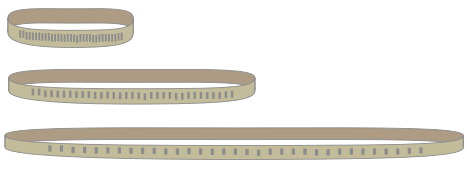
Color models are strategies to describe an image so that it can be stored and processed as digital data. Although there are many color models, the most important for still images are RGB and CMYK. RGB is an acronym for Red, Green, and Blue, the three primary colors. By adjusting the proportions of these three colors most other colors can be created. CMYK stands for Cyan, Magenta, Yellow, and blacK, the four colors of standard offset printing ink. (k so that it can't be confused with the b in blue.) Most of the time you will work with the RGB color model, which is suitable for viewing on computer screens, projecting with digital projectors, or, because the conversion is built in to their drivers, printing with an inkjet printer. An RGB image describes a wider range of colors, or gamut, than a CMYK image, making it more suitable for use in a master file.

Pixels

A digital image is made up of *pixels* arranged in rows and columns. Each pixel represents a small part of the image, and is represented digitally by a number representing values along a scale from light to dark. An image's *image size* is the measure of its pixels, measured in the horizontal and vertical axes, so that a 1200 x 800 image is 1200 pixels wide by 800 pixels tall. If the pixels are close enough together, they read as a smooth continuous tonal range and you don't read them as individual dots. This pixel density or *resolution* determines how smoothly the values in an image appear. The image size, or absolute number of pixels in the image, determines how large the image can be displayed at a given resolution.



Resolution is measured in pixels per unit of length, for us, pixels per inch. To print smoothly, most printing applications require a resolution of at least 240 ppi. For web use or other screen-based images, the target resolution is 72 ppi. Some basic math will lead you to the conclusion that for a given image size, a screen-based image will be rendered larger than one that is properly sized for print, and a printed image requires a larger image size to appear at the same length and width as a web image.



The easiest way to understand the interaction of resolution and scale is to imagine the pixels of an image mapped to a rubber band. The rubber band has a fixed number of points marked on its length that represent the image's pixels. As you stretch the rubber band, its length increases and the marks get farther apart, but they do not increase in number. When the pixels are very close together they appear as a continuous tone. If the rubber band is stretched and the pixels get too far apart they no longer read as smooth values. This is why you cannot arbitrarily enlarge a digital image without having it look "blocky", and why it is important to capture the maximum resolution you are capable of when you photograph your work.

! Note that it is possible to display any image size at any resolution—1200 ppi, for example. It is only when you also specify a physical dimension with that resolution that you run into the potential for a limitation. A an image that is 600 pixels by 400 pixels will appear ½ by ⅜ at 1200 ppi, but would need to be 4800 by 3200 to reproduce at 4 x 3". Unfortunately it is common to specify only part of this equation—the resolution—without specifying the size, so a request will be made for images "at 300ppi." This is not enough information to know how to fulfill the request. Likewise, a request for an image that is 5 x 7 fails to specify the resolution and can't be fulfilled without additional information.

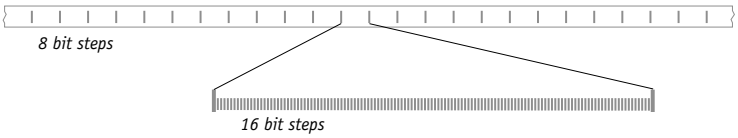
Channels

A *channel* is the part of an image's data that describes one particular aspect of an image's color model. In a grayscale image there is a single channel that describes how light or dark a pixel is. An rgb image is made up of three channels, each holding the value of *R*ed, *G*reen, or *B*lue for each pixel. A cmyk image has four channels, one for *C*yan, *M*agenta, *Y*ellow, and blac*K* ink. Every channel contains a full set of information for each pixel in the image.

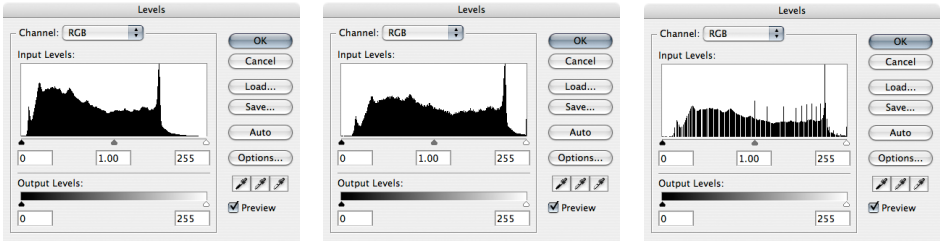
Several image formats (.tif, .psd) can also hold additional channels that are used to store information about how to display an image. Often called *alpha channels,* these are used to hold instructions for displaying only part of the rectangular image or to save masks and selections you build in Photoshop.

Image Depth

Image depth or *bit depth* is the size of the binary number that stores an image's pixel information. It affects the final quality of edited images. The smallest possible depth is in a black-or-white image, which has an *image depth* of one bit. The pixels in this image are either black or white. Grayscale and color images are displayed and printed with 256 steps, or an image depth of 8 bits, per channel, yielding the possibility of just under 17 million different values for each pixel. This may seem like a lot of values, but because of the fact that each of these values is visible in final prints, there are times when this is not enough values to prevent banding and other artifacts.



When corrections are made to an image's lightness or contrast, original values must be rounded to the nearest whole value in the editing process, resulting in the possibility for skipping levels that become visible in a smooth gradation. The solution is to work with your images at a higher image depth. A 16 bit image theoretically (but not quite practically) provides another 256 steps inside each single 8 bit step. This eliminates most of the rounding issues associated with 8 bit images, but comes at the cost of doubling the file size. Many scanners provide 16 bit images, as well as cameras that will save a raw file. In all cases where image editing will need to be done, a larger image depth is better than a smaller one. These Photoshop histograms show the difference between editing in 16 bit color and editing in 8 bit color. The gaps in the right hand histogram are from rounding to the nearest whole number of steps when making adjustments. They will print as a "step" in a smooth gradation.



Original 16 bit image *After adjusting in 16 bit* *After adjusting in 8 bit*