Pixels and Dots

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I have often wondered what goes on in a photo printer and what I can do to make my prints look better. After hours of research and study, I have determined that I will never know what goes on in a printer and there is not much I can do to make my prints better except for extensive editing. But, the subject here is printing. I did learn a few things that I think are interesting and maybe helpful. Perhaps you will think so too.

I have read a number of articles in the press and on the Internet that start out defining “pixels” and “dots” and then misusing the terms later in the same article! While it may not be a subject that will shape the future, I feel better about printing my pictures if I at least think I know a little about what is going on. Software and printer suppliers have made the process of printing photographs as painless and foolproof as possible. So, why do I sweat it? There is probably not much I can do to improve my prints by knowing the difference between a pixel and a dot. But, if you share my desire to know a little bit about what is happening, then read on. Right off the bat, there are two other terms we must understand. They are “picture” (or “image” - they can be used interchangeably) and “print.” Pixels are associated with pictures or images and dots are associated with prints. Remember that.

What is a pixel?

A “pixel” is the smallest division of a scene in a digital camera or computer or scanner. That is to say it is the building block or basic element of the picture. It is a tiny speck of color that, when combined with millions of others, makes a pretty picture. They are quantified as “pixels per inch” (ppi). But, the camera and computer and scanner are as far as pixels go. *There are no pixels in a printer*. Digital cameras have chips covered with light sensitive sensors - millions of them. Each sensor is covered with a color filter so each sensor only records one color. Three sensors, grouped together, constitute a “pixel.” The information from these three sensors is lumped and coded. Put a picture into a photo editing program and blow it up to the maximum (like 1600%), the individual pixels will show if you pick an area in the picture that is multicolored. Using the color pickup tool in the editor you will be able to determine the exact description of that color. For instance I am looking at a picture of a yellow rose and the pixel color I picked up is 155 red, 131 green and 41 blue. These codes go from zero to 255 so there are 256 shades for each color (or more but I can’t explain how that is done). This allows for 16,777,216 (256x256x256) combinations! This takes us to**...**

What are dots?

“Dots” are multiple drops of ink in one spot on a piece of paper. They are quantified as “dots per inch” (dpi). They get there in a printer. My printer manufacturer claims my printer can deposit 32 drops of ink on one spot. It’s a wonder there isn’t ink all over my desk top. Other manufacturers do it some other way. Some call it “dithering” and I am sure the results are similar but I do not know what dithering means. If we are considering only three colors (CMY), there are 6545 possible combinations of 32 drops of ink. If we add light cyan, light yellow and three shades of gray (as my printer does), this number gets much larger but nowhere near 16,777,216. This leads us to conclude that we *must use more than one dot to represent a pixel*. (Exception: thermal dye printers, sometimes called dye sublimation printers, can produce any of 16.7 million colors on one spot so one dot per pixel will work fine.) With inkjet printers four dots per pixel does a pretty good job but nine or sixteen are better, I suppose. I think any more than that is overkill. Printers and their associated software can put down a cluster of dots that are close to the desired color but scattered around the color such that when blended by the eye, it looks like the desired color. (See example at the end.) So, one rule of thumb is, if you can, set your printer for four times the number of dots per inch as your picture has pixels per inch. i.e. If your picture has 150 ppi, then set your printer for 600 dpi. This gives you 16 dots to simulate each pixel (4x4=16). *Remember this – pixels determine detail and dots determine color rendition*. You cannot improve detail by

increasing the dots per inch but you might improve color quality. Here is a table that may be of some help:

Camera Rating	Picture Width x Height (pixels)	Maximum Print Size at 150 ppi (inches)	Printer Setting (dpi)
1.2 Mp	1280 x 960	8.5 x 6.4	600
3.2 Mp	2048 x 1536	13.7 x 10.2	600
4.0 Mp	2290 x 1720	15.3 x 11.5	600
		at 200 ppi	
1.2 Mp	1280 x 960	6.4 x 4.8	800
3.2 Mp	2048 x 1536	10.2 x 7.7	800
4.0 Mp	2290 x 1720	11.5 x 8.6	800
		at 300 ppi	
1.2 Mp	1280 x 960	4.3 x 3.2	1200
3.2 Mp	2048 x 1536	6.8 x 5.1	1200
4.0 Mp	2290 x 1720	7.6 x 5.7	1200

Notice the columns on the left have to do with the *picture* and the columns on the right have to do with the *print*. You combine the two by deciding what amount of detail you want in the picture to be printed, say 200 ppi. Divide that number into the number of pixels in one dimension of the picture, say 2290. The result is you can have an 11.5 inch print with a 200 ppi resolution and that, if you can, you want to set the printer at 800 dpi. Needless to say, you can never get exact multiples of dpi/ppi but don't worry about it. The software geniuses can handle it. If you can manage to have somewhere between two and four times as many dots/inch as pixels/inch, you will most likely be very satisfied with the result.

But, what does it take to make a satisfactory result? I have read that tests have shown the human eye can discern objects only .003 inches by .003 inches. That corresponds to 300 ppi. So, as a starting point, 300 ppi results in a museum quality print. Any finer than that is wasted pixels. Now then, what are you willing to settle for? I am the original "Cousin Weakeyes" and cannot differentiate more than fifty or a hundred colors so I am quite happy to print 200 ppi pictures from my 3.2 megapixel camera at 8x10 inches using the standard 600 dpi setting ("best" on my printer). When you consider all the other goofs I make as a photographer, this is the least of my problems.

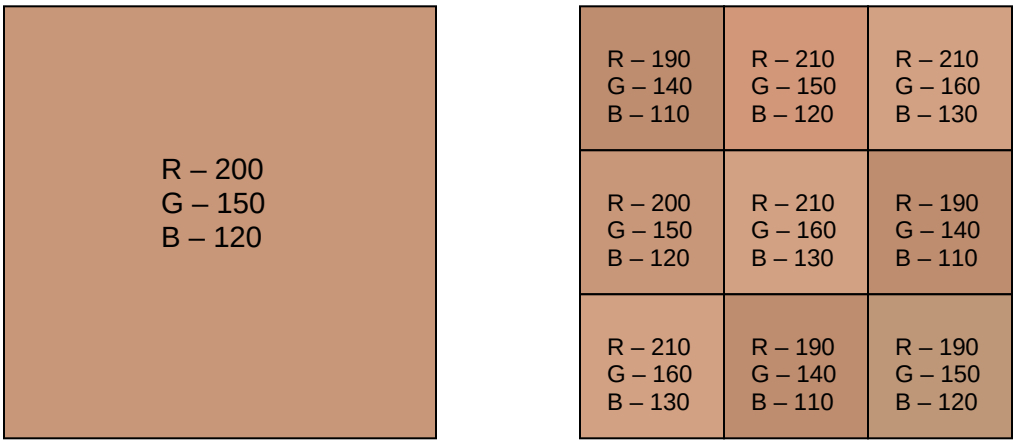
Picture Size

Picture size is measured as (pixels)x(pixels). If you load your 2290 x 1720 pixel picture into a photo editor and click on "Picture Size" or some similar button, it will say your picture is 31.8x 23.9 inches at 72 ppi. Of course no one wants a picture with those specs. So, you are given the opportunity to "rescale" or "resize" the picture. What the heck does that mean? First, *resizing* (or *resampling)* means to change the number of pixels that make up the picture. Remember that *size* is measured in pixels so resizing means changing the number of pixels. This is done with various and wondrous mathematical algorithms that are not understandable by ordinary humans (and I am very ordinary). I never *increase* the size of a picture because that means adding pixels but I do *reduce* the picture size to send with an email or use on a web site. But, that is another subject. (See the chapter on Emailing Pictures.) What we are interested in for printing purposes is *rescaling* a picture. That is where we (usually) push the given number of pixels closer together. Think of a picture printed with a bunch of dots on a stretched rubber sheet. If we let the rubber relax, the dots come closer together and the picture improves. So when we push the pixels together from that 2290x1720 pixel picture for an 8x10 inch print, we end up with about 220 ppi

and that will make a very nice picture. You can do this in the photo editor or you can take the lazy person's approach and let your printer software do it. Most, if not all, printer software has a button or check box somewhere that says something like, "Make it fit the paper." That works.

In summary, you probably do not have to know any of this to make good prints from good pictures. Printer manufacturers have done a marvelous job for us. I just thought you might like to know.

Note: On 04/20/05 PC Magazine published an article by M. David Stone that says almost exactly the same thing as I have said in this article with an entirely different literary style, of course. He is an expert. This made me feel very good. You can access his article by going to pcmag.com and looking for the article named "Prints and the Resolution."



Just pretend the pixel on the left is a color that the printer cannot exactly duplicate. So, on the right, it deposits nine dots in a pattern of colors it can print that are clustered around the desired color. The test is that if you look at these from a distance of twenty feet or more, they look alike. Don't be too picky, now.