The relationship between Image Resolution and Print Size

This tutorial deals specifically with images produced from digital imaging devices, not film cameras.

Make Up of an Image.

Images from digital cameras are composed of PIXELS, Pixels take their name from the combination of two words, PICture and ELement, but PICEL is an odd word to say, so I assume it was modified to PIXEL.

Once your camera has processed the information gathered by the light sensitive pixels contained on your sensor, it generates an image consisting of coloured pixels and saves this file to the storage memory card.

If you load an image into your editing software and zoom in, eventually you can see the individual pixels that make up the image. See fig. 1 below.

Fig 1.

Zoomed in view showing the individual pixels that create the image.
In general terms, the more pixels contained on your sensor, the more detail your camera should be able to resolve. There are separate issues to do with size of the sensor and therefore the size of the pixel that will affect this level of detail.

What are These Issues?

Well, let us consider a full frame sensor. It may contain 16.2 Million Pixels, but because the sensor is large (Full Frame), the pixels are also large. Whereas a smaller APS-C sensor (Cropped Sensor), which also has 16.2 Million pixels, will have smaller pixels also.

In principle, larger pixels gather more light for a given exposure, so tend to have a better signal to noise ratio than the smaller pixels. This gives better image quality. This is just an example to illustrate the point, as it also depends on how much background noise each sensor generates and how good the computer firmware in the camera is at reducing this noise. It does not apply in every case. Always consult valid test data before buying.

Getting Back to the Point

One big advantage to having a camera with a high pixel count is that you can crop the image to a given degree and still print it at a high enough resolution to get acceptable prints.

What is the meaning of ppi and dpi and what is he difference?

**ppi** = pixels per inch and **dpi** = dots per inch and the two are most definitely NOT the same.

When we first take a photograph with our digital camera and then load it into our editing software it displays on the screen as a full size image. Let us take the example of the APS-C at 16.2 million pixels. This produces an image approx. 4928x3264 pixels. Our computer monitor screen has a resolution of only 1600x1200 pixels, or even less, so it cannot display the photograph at full resolution whilst still showing the whole image. We would need a screen with 4928x3264 pixels.

If we zoom in to 100%, a large part of the image will disappear off screen.

See images Fig.2 and Fig. 3 on the next page.
When we look at a full size photograph on our monitor showing the whole picture, the graphics card is interpolating the image and not displaying the whole information, so the image is displayed at a reduced quality. In other words it dumps some image pixels from the displayed information, not from the file.

When we display the image at 100% zoom, the graphics card maps the image pixels to the screen pixels 1 to 1, so you see part of the image at full resolution. This is sometimes referred to as ‘pixel peeping’. It will show up any artefacts, such as over sharpening halos very clearly.
Projected Digital Images

Projectors have a fixed maximum display resolution. They vary from 1024x768, through 1400x1050 to even higher levels. It is for this reason that we resize our image for Digital Competitions to fit within this finite rectangle.

The process of reduction actually deletes from the image file a vast amount of information, taking the image from 16.2 Mp down to 1.47 Mp or so. We must be careful not to confuse size with resolution. The reduction reduces the size of the image, that is to say, less pixels in the file, but the projector still determines what is shown. It is a fixed number of pixels in each direction independent of resolution.

If we tried to display an image bigger than the native resolution, the projector would only show part of the image unless it had its own reduction software to reduce the image to the projection pixel count.

Monitor displays.

Our computer monitor screens can vary the quality of the display as we zoom in and out of the image, but the maximum number of pixels that can be displayed is controlled by the number of pixels on the screen. In the case above this is 1600x1200 pixels. As we zoom in and out the computer re-samples the image to show what we want to see in relation to the number of screen pixels available.

When displaying an image reduced to 1400x1050, it follows that this can be displayed fully at 100% on a 1600x1200 screen. To get the best possible quality image on screen then with a full size image, this is only provided at 100% zoom. To minimise the impact of this re-sampling it is suggested that we use a zoom factor that is 25%, 50% or 75%. For image sharpening use a screen zoom factor of 100% or 50% for best visual results.

So what is dpi?

Dots per inch is the measure of the number of ink droplets an inkjet printer will place per linear inch to lay down the image on the print paper. Modern high end inkjet printers have resolutions as high as 2880 dots per inch horizontally and 1440 dots per inch vertically (some are even higher). This suggests of course that the droplets are oval not round or that multi passes of the print head occur.

In the brochures for inkjets you may read that the printer can vary the droplet size and it might be thought that this technology is infinitely variable, but often it is limited to just two sizes, full size and half size with \( \frac{1}{2880} \) of an inch being the smallest. If we print at 1440 dpi, the printer may either double the droplet size or lay two droplets side by side, but it is hard to know the secret workings of the printer.

What does this have to do with getting the best possible print quality?

We are told that the best ppi (Note PPI) to use for high quality prints is 300. What is meant by this is that this is the minimum number of image pixels per linear inch to give an impression to the viewer at a reasonable viewing distance that the picture is analogue. That is to say it appears to flow continuously to the human eye rather than appear as a row of dots. This is related to something called the Circle of Confusion, which has been covered in another tutorial.
But, 300 ppi does not give the best print quality!
Let us consider what is happening when we print an image made up of a definitive number of individual pixels. Normally, we want our image on the paper to be of a size that best fits the size of the paper. We do not want to print a postage stamp in the middle of an A3 sheet.

So what do we do?

Take a look at fig. 4 below.

![Image Size](image.png)

Fig. 4

Assuming we are printing to an A3 sheet which is 420mm x 297mm, if we accepted the settings shown, the image would be off of the edge of the paper because at 240 ppi the image size is 487.26mm x 280.25mm, far too big.

The normal thing is to reset the image size without re-sampling the image. So turn off ‘Resample Image’ (click it to remove the tick).

Change the image resolution to 300ppi.

Check that the height and width are still within the paper.
This gives us an image size on the paper of 398.81mm wide x 224.2mm tall at a resolution of 300ppi.

Well that’s ok then, it fits the paper and it is of a higher resolution at our target 300 ppi.

But it is not going to give us the best possible print quality for the following reason:

We have already established that our printer can lay down 720, or 1440 or 2880 dots of ink per inch onto the paper. So in the above example, we are asking the printer to print 300 pixels for every linear inch at 2880 dpi. Doing the maths we find this:

\[
\frac{2880}{300} = 9.6 \text{ ink droplets per pixel.}
\]

Well the printer cannot do this, so it has to dither and adjust the number of droplets to what it can print per pixel, so it may lay down 9 for the first pixel, then 10 for the next, attempting to approximately stick each pixel on the paper where it should be. But this introduces softness.

The difference is tiny, but if you are seeking the highest possible print quality for an exhibition or a top end competition, it is not the best way to proceed.

**So what do we do then?**

The best solution is to set the dpi value to something that is a whole multiple of 2880. This means printing at the following resolutions:

- 180 ppi – OK if the image is not going to be looked at closer than say six feet (2.0M). Bill board posters are often printed at this or lower resolution. It gives 16 ink droplets per pixel.
- 360 ppi – Best possible for club A3 prints as it gives 8 ink droplets per pixel and lays every pixel on the paper in its correct position. The image size is also acceptable.
The image on the paper is approximately 324mm x 186mm giving a border of 48mm to the sides and 55.5mm to the top and bottom. This is smaller than you may wish, but gives best results. If your camera resolution is higher, you will get a bigger printed image.

These examples are for a 16Mp camera. If your sensor has more or less pixels, then these values will need to be adjusted. But the principle remains the same. Try to use a ppi that gives a whole number of ink droplets per pixel.

**Printer Settings and Paper Types.**

I use an Epson Pro3880 A2 printer, but only because I need A2 paper format for my business use. Epson printers use Pigment ink, some other makes use dye based inks. A3 printers are available with the same ink set.

What is the difference?

Well, pigment ink contains finely ground coloured powder and dye based ink does not. The technology behind pigment ink is complex, the pigment needs to be extremely finely ground so that it passes through the print nozzle without causing blockages and the suspension fluid needs to retain the pigment in suspension, so that it does not settle out to the bottom of the cartridge.

For these reasons, some users have had problems using cheap lookalike ink. Buyer beware! Both inks need to be colour-fast, so that they do not fade in normal use. The top manufacturers now claim 100 year survival rates providing the prints are stored carefully, so that problem seems to have been solved. It is still worth mounting and storing your prints on and in acid free card and sleeves.
The other thing that greatly influences the quality of both coloured and monochrome prints is the variety of ink colours available to you. Many low cost printers will just have three or four possibly, CMYK or Cyan, Magenta, Yellow and Black. From this combination it should be possible to print the full range of the sRGB colour space. But these printers will have difficulty printing high quality monochromes, as they must use the colours to mimic shades of grey. They also may not offer the extended AdobeRGB colours either.

High end printers will have a much wider colour palette and a wider choice of ink colours, as well as several grey options enabling high quality monochrome printing. The Pro3800 has two blacks, Photo and Matte as well as two greys, Cyan, Magenta, Light Cyan, Light Magenta and Yellow. The later Pro 3880 has bright light Magenta and bright Magenta.

**Paper Types**

Most printers will support shiny and matte papers. There are various types of both on the market and not all paper types are suitable for all printers, so check your printer driver to see what you can use. In principle, it seems best to use the ink and paper manufactured by the same company that made your printer. This is simply because they will be perfectly matched to each other. The paper absorption rate will match the ink drying characteristics so you will not have problems of smudging or of ink droplets bleeding into each other, causing colour variations.

The base colour of the various papers will also vary. You may see on the box reference to the paper whiteness and brightness values. If you compare different papers, you will see that the original background tint may be bright white or it may have a slightly buff appearance. This will affect the tones in your image when printed, especially in the highlights. Soft off white paper is sometimes preferred by portrait photographers, whilst natural history photographers may use a whiter paper.

There are also specialist Art papers, such as Cotton rag and Canvass, but they can be expensive and may not suit your printer.

The choice of paper may also affect the sharpness of your image. Matte papers vary in the maximum dpi they are able to support; some have a top limit of 1440dpi, whilst others will work at 2880dpi. Some lower quality matte papers may bleed more, tending to soften the image. Try to obtain test samples before buying if possible.

**Profiles**

You should always colour profile your monitor and repeat the process at regular intervals if you want good colour control. You must also use the correct paper profile setting for your printer. If your printer comes with built in profiles for the paper type you are using, then select it. If you are using third party paper, you have a choice of using the generic profiles supplied by the paper manufacturer or using a custom profile.

A generic profile is one that is built from a printed colour chart produced on a printer of the same make and model as yours. It will be a near match, but may not give the best result possible. If the printer used for this has a slight tendency to give a colour cast that your printer does not, the profile will correct for this and give you a bad print. The custom colour profile built from a test patch printed on your own printer will correct any deviations that your printer suffers from and therefore will give a true result matching your profiled screen.
Image Sharpening

Finally, we come to the subject that probably offers the biggest challenge and the most confusion of all of the printing workflow stages. Do we need to sharpen our images and if so, by how much.

This is a subject all of its own, too complex to cover here in detail. Basically, the answer is YES we do need to sharpen ALL digital camera images, but carefully and selectively.

Sharpening routines in programmes such as NICK have advanced features and offer the user the option of painting sharpness in selected areas using a brush. Far more advanced than just global sharpening. Worth considering rather than spoiling an image at the last stage before printing.

David Ryland LRPS