

Technical Tip – Image Resolutions for Digital Cameras, Scanners, and Printing

One of the most confusion issues associated with digital cameras, scanners, and printing involves image resolution. This document will provide some explanations and general "rules of thumb" to address resolution issues.

About Resolution – What Is It?

Camera resolution is expressed differently than scanning and printing resolution. Camera resolution refers to the total number of pixels that are used to make up an image. It is calculated by multiplying the width in pixels by the height in pixels. For instance, a camera may make an image that is 640 pixels wide by 480 pixels high, or perhaps 1280 pixels wide by 960 pixels high. A 640 x 480 photo has 307,200 pixels and a 1280 x 960 photos has 1,228,800 pixels. The greater the number of pixels, the larger the file size of the digital image.

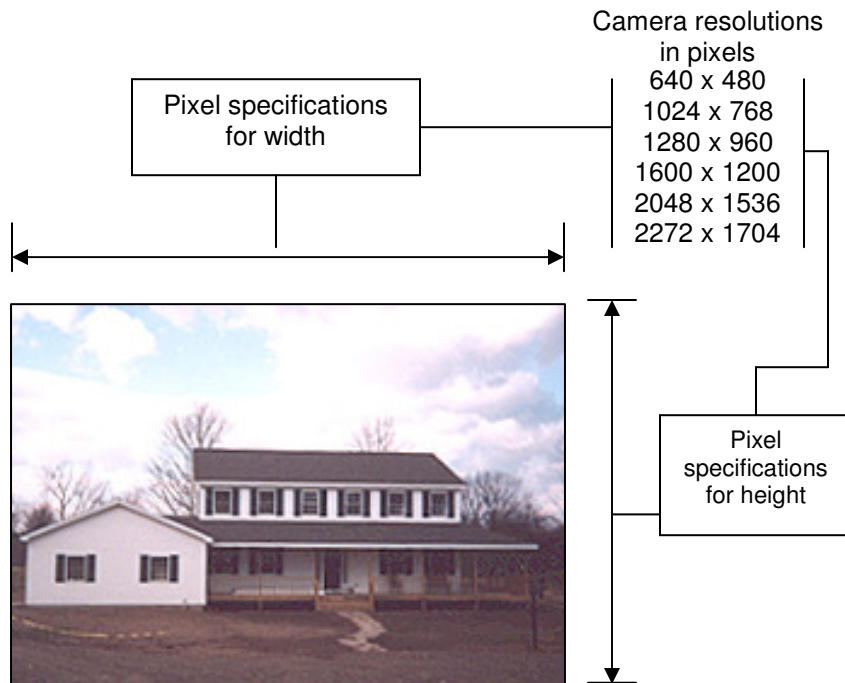
Scanners and printers express resolution in **dots per inch, dpi**. A scanner may scan at 100 dpi, 150 dpi, 300 dpi, 600 dpi, or even higher. Usually the scanner setting is adjustable. The rule of thumb is that the greater the dpi, the better the image quality because more data is being used to make up the image. However, some scanners and their associated software produce high scan dpi using interpolation. The scanners scan at an "actual-high" resolution, but the software increases the dpi through an algorithm. This may or may not result in higher quality. There are too many variables to say for sure without testing.

Inkjet printers typically print at 150 or 180 dpi. Although many of them can be set to print at a higher resolution, such as 300 dpi, the results are often unsatisfactory. Print quality depends on many factors. These factors include how well the print head will spray the small droplets of ink that make up the image and the quality of the paper. Poor paper and a dirty print head will cause an image printed at 300 dpi to look worse than one printed at 150 dpi.

Commercial printers use different technology to reproduce images. High quality artwork, calendars, and postcards may require printing at 300 dpi. The requirements for good commercially printed items are likely to be quite different than simple inkjet printer projects.

Resolution, Image Size, and Printing

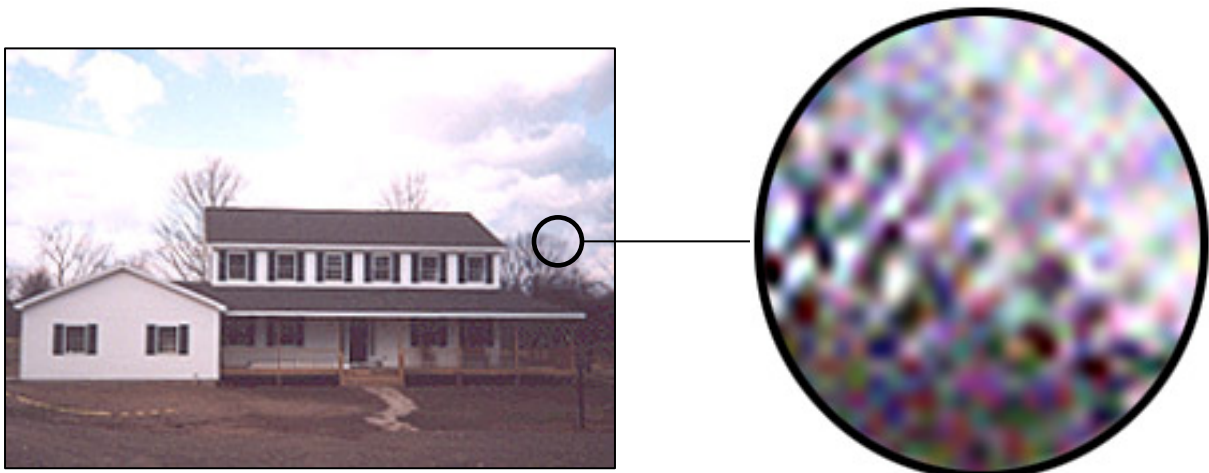
As mentioned above, resolution for cameras is expressed in the number of pixels used to form the photograph. When discussing the camera, the pixels do not refer to a physical size for an image. Instead, the number of pixels refers to the quantity of pixels used to make up the image.



The photo shown above could have been taken at any of the resolutions specified, as long as the camera was capable of taking a picture at that resolution. In theory, a photograph taken at any of the resolutions listed above may be printed in any size. However, there are practical limitations associated with the print resolutions and the capabilities of the printer.

Printer resolutions, unlike camera resolutions, are specified in dpi, **dots per inch**, or ppi, **pixels per inch**. An inkjet printer sprays small droplets of ink onto paper. As mentioned above, the typical printer sprays these droplets at a resolution of about 150 or 180 droplets per inch.

The illustration below demonstrates what we might see if we were examine a portion of the printed photograph under a microscope.



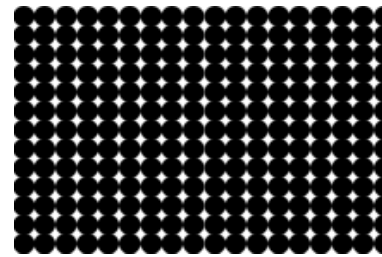
Problems arise when attempts are made to print a photograph that was not taken at a high enough camera resolution. For instance, a simple example is a photograph snapped at 640 x 480 camera resolution. The width of the photo in pixels is 640. A usual size for photos at this resolution is "3 x 5," meaning 3 inches high and 5 inches wide.

NOTE: Confusion is often caused by the common habit of referring to prints in "height by width" terms and camera resolutions in "width by height" terms. This is an outgrowth of how prints have been described throughout the history of photography and the more recent development of computers and electronic media.

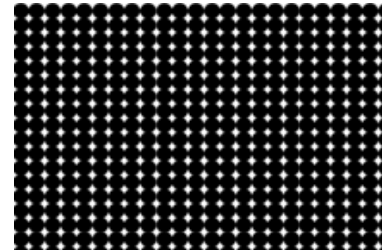
The 640 camera pixels have to be spread out over a 5" width when the photo is printed. This turns out to be about 128 pixels per inch of print. This is slightly lower than the typical printer resolution, 150 dpi, but will probably render an acceptable print if the quality of the printer and paper is satisfactory.

But if the same photo is to be printed at another common size, such as 5" x 7", the same 640 pixels have to be spread out over 7" of print width. This results in a print resolution of only about 91 dpi. The print will be very coarse and grainy.

The diagram on the right represents the 5" x 7" print's appearance under a microscope.



The diagram on the right represents the 3" x 5" print's appearance under a microscope.



Because there are more dots per inch of photo, the print will have a much better appearance.

This means that the general "rule of thumb" is that the higher the print resolution, the higher the quality the resulting printed image. High print quality can be described two ways:

- 1 – For any specified print size the camera resolution should be as high as possible. This results in lots of dots per inch for a print.
- 2 – For any specified camera resolution the print size should be as small as possible. This also results in lots of dots per inch for a print.

Other basic rules are:

- A – A high camera resolution will allow a large size print because there are more "dots to spread around."
- B – The quality of the finished print is only as good as the number of dots per inch at which it is printed.
- C – The printer specifies the number of dots per inch at which a photograph is printed.

NOTE: Printers will have a maximum practical resolution at which a photo can be printed. While most inkjet printers typically print at 150 or 180 dpi, many can be set to print at higher resolutions, such as 300 dpi. However, the crowding of the ink droplets can cause the print to appear muddied. Therefore, while the resolution may be higher, the actual quality of the print will not improve.

Other factors in print appearance include the type of paper used. Good quality paper will result in sharper prints. Some printers work best with certain paper. It is often necessary to experiment to find the proper combination of resolution, printer, and paper.

Scanner Resolution verses Camera Resolution

Scanner resolution is the resolution at which an image, such as a photograph, is scanned. Unlike a camera, the image that a scanner creates is based on the established size of the object being scanned. This sound a little confusing, but it really is not.

Digital cameras create photographs with resolutions based on the total number of pixels in the image, not on a finished print size of the photo. The printer determines the print size based on the judgment of the operator. But scanners start out with a document that already has a specific size. In the case of a photograph, the size may be 3" x 5", 5" x 7", or any other set of dimensions.

It is then necessary for the scanner to create an image file based on the original document's dimensions and desired resolution. For instance, a photograph that is to be used on a Web site will typically be scanned at 100 dpi because that is similar to the optimum resolution for PC monitors which make up over 90% of monitors in use today. But a photograph that is to be scanned so a copy can be printed on an inkjet printer will be scanned at 150 dpi because most inkjet printers print at 150 dpi.

But a photograph that is being used for high-quality printing purposes, such as postcards, calendars, and posters are likely to be scanned at 300 dpi, or higher, because the professional printing systems print at higher resolutions. These printing systems create the highest quality reproductions.

Both camera resolution and scanner resolution has to be high enough to do the job required. The techniques for obtaining those resolutions are different in each instance. Knowing how those resolutions are determined allow you to create an image file that is appropriate for each purpose. In the case of professional printing, the print shop will provide the specifications they require for the image. As an example, the printer could say that they need a file for a photograph that is equivalent to a 5" x 7" image at 300 dpi. If you are taking a photograph especially for the project you will be able to set the camera accordingly, if the camera is capable of that resolution. On the other hand, if you are scanning an image, you can set the scanner resolution to match the requirements.

Typical Camera Resolution and Print Sizes

There are many different sources for information regarding what resolutions to use for which print sizes. Unfortunately, not all sources agree as to what works best when. However, the data listed by most sources can be lumped into general categories. While the categories may not be correct for all instances, they are usually good enough to get started. It is a good idea to check the camera's manual for information regarding settings.

The chart below contains general information about settings and resolutions. It should be helpful in most instances where photographs are being taken for print purposes.

NOTE: The sizes listed above are approximate. The general rule is that the higher the camera resolution, the larger the print. Small prints from high camera resolutions are more likely to look good than large prints from low camera resolutions.

The data listed in the chart do not reflect other factors such as the photographic technique. Blurry or dark photos remain problems that are best cured by improving photographic practices.

A Word about Image Editing

Image editing programs can be used to manipulate photographs. Within reason, programs such as Photoshop, Fireworks, or Illustrator from Adobe (www.adobe.com), or even Irfanview (www.irfanview.com) may be used to crop photos, adjust brightness and contrast, or even improve sharpness. But, it is important to remember that an editing program can only work with the data that is contained within the original photograph.

Photos with high resolution have more data, and thus larger file sizes, than photos taken at lower resolution. While it may be possible to increase the resolution of a photograph, the change almost always results in a print that will be have physically smaller dimensions. Big prints require big

Typical Camera Setting	Size in Pixels	Maximum Acceptable Print Size at 150 dpi
640	640 x 480	2" x 1.5"
1024	1024 x 768	4" x 6"
1280	1280 x 960	5" x 7"
1600	1600 x 1200	8" x 10"
2048	2048 x 1536	10" x 15"
2272	2272 x 1704	11"x17"

files; big files are photos with high dpi; photos with high dpi are snapped at high camera resolutions.

Although may be possible to improve dark photos using an editor, it is not possible to bring out detail that does not exist if there was not enough light used to make the photo. Software will not make up for poor photographic technique. The photo of a black cat in a coal bin at midnight will always be blank if there was not enough light. The cat may have been in the coal bin, but unless an appropriate amount of light makes it into the camera the cat may as well be invisible. A photo-editing program will not "manufacture" light.