Understanding Resolution and the meaning of DPI, PPI, SPI, & LPI

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Understanding DPI, PPI, SPI, and LPI

By David Creamer

Scanners: SPI (samples per inch) or PPI (pixels per inch)

PPI (pixels per inch) works for scanner input, but technically, SPI is more accurate. For example, if you scan 200% at 300 PPI or if you scan at 100% at 600 PPI, the scanner "sees" the same data. The PPI is different for each file, but the sampling of the original by the scanner is the same. Maximum SPI of a given device is the optical resolution at 100%.

SCAN TIPS

Always scan at no more than your maximum optical resolution. This number is not the large number advertised on the box (9600 PPI resolution!), but the smaller number tucked away somewhere in the specifications. If your scanner has a 1200 SPI optical resolution and you determine that you need an image resolution of 300 PPI, you can scan at a maximum of 400% (300 PPI x 4.00 = 1200 PPI).

If you determine that you only need 266 PPI for your images, scan at a "native" resolution of your scanner. If you have a 1200 SPI optical resolution scanner, scan only at 1200, 600 (200% maximum scan), or 300 (400% maximum scan) PPI. Then change the resolution to 266 PPI in Photoshop after you are finished scanning.

Digital Cameras: Width x Height Pixels only

A digital camera can capture data based on the mega-pixel ability of its CCD. For example, a 2 mega-pixel digital camera shoots at approximately 1600x1200. 1600 pixels times 1200 pixels = 1,920,000 total pixels (rounded up).

Usually the camera images have no resolution assigned to them (although some cameras can do this). When you open the file into an image-editing program, such as Photoshop, a resolution HAS to be assigned to the file. Most programs, including Photoshop, use 72 PPI as a default resolution.

Monitors: Width x Height Pixels only

Monitor resolution is measured by pixel width and height. Some common settings are 800x600, 1024x768, 1280x1024, and 1600x1200. Different size monitors could be set to the same resolution, so there is no default pixels PER INCH setting for monitors. The old default of Mac monitors displaying at 72 PPI and Windows working at 96 PPI went away with multi-sync monitors. However, as mentioned, some programs have to ASSUME a default resolution, so you will still see those numbers used.

Web & Video Graphics: Width x Height Pixels only

Web Graphics also are measured by pixels only, usually in relation to a monitor size. Basically, one image pixel from a web graphic displays as one monitor pixel*. A web graphic that is 800x600 pixels will completely fill up a monitor set to 800x600, but only fill 25% of the screen of a monitor set to 1600x1200.

*Actual pixels (100%) in Photoshop also display one image pixel for one monitor pixel. (Web-only graphics programs, such as ImageReady, do not assign resolution to graphics and work strictly by pixel dimensions.)

Video graphics work the same as web graphics except they have some pre-determined pixel settings. A typical video setting for TV projection would be 720x480 pixels (surprisingly low resolution compared to print). Of course, HDTV could have higher settings.

Image resolution for printing: PPI (pixels per inch)

(If you are using commercial printing, it may be useful if you read the LPI and DPI sections first, before reading this section.)

For print, images need a minimum resolution, measured in pixels per inch, in order to have enough detail and look natural. The amount of resolution required depends on the type of printer used and the LPI. For example, for conventional commercial printing, the resolution required is approximately 1.5 times the LPI (although some still suggest 2 times the LPI). So when printing at 150 LPI, the image resolution should be 225 PPI (or 300 PPI if using the 2X method). For ink jet printing, usually a resolution of 150-200 PPI is all that is needed.

Excess resolution is not used when printing and only does three things: make your files larger than necessary, increase the printing time, and it can have the effect of "softening" your images. The best solution is to have the maximum amount of resolution REQUIRED, based on your final image size, your printing method, and line screen used.

Commercial Printing

Printing Method	1.5 X Method		2 X Method	
	PPI	File Size for CMYK 8x10 in. (in MB)	PPI	File Size for CMYK 8x10 in. (in MB)
Newsprint — 100 LPI	150	6.9	200	12.2
Magazine — 133 LPI	200	12.2	266	21.6
Magazine — 150 LPI	225	15.4	300	27.5
Brochure — 175 LPI	263	21.1	250	37.5
Brochure — 200 LPI	300	37.5	400	48.8

Inkjet Printing

Printing Method	Standard Image		High-Detail Image	
	PPI	File Size for RGB 8x10 in. (in MB)	PPI	File Size for RGB 8x10 in. (in MB)
Inkjet — 1440 DPI	150	5.2	200	9.2

Printing Screen Frequency: LPI (lines per inch)

Using black-only print job as an example, we mimic grays by printing various sized dots of solid black ink. A group black dots lets some of the paper show though (usually white paper), and the blackness of the dots and the white of the paper blend optically to look like a shade of gray. Depending on the size of the black dots, the gray looks darker or lighter. However, in a given print job, the SPACING of the dots is the same (for conventional printing). The spacing is referred to by these names: screen frequency, line screen, or more recently, lines-per-inch (LPI). The LPI is usually determined by either the printer (for desktop printing to laser printers), or by the quality of paper used (for commercial printing).

Line screens are easiest to see in a newspaper since the cheap paper requires that the dots be spaced far apart due to press dot gain (the ink soaking in and spreading out on the paper). The same principal applies for spot-color printing and process-color printing (CMYK).

Printer resolution: DPI

Laser printers can print at various settings up to their maximum resolution. For example, a 1200 DPI printer could print at 600 DPI or even 300 DPI.

The number of gray levels a printer can mimic is directly related to the DPI of the printer and the LPI used. Using the formula below, we can determine how many levels of gray can be printed at a given line screen at a given printer resolution.

$$(\text{Output Resolution} / \text{Screen Frequency})^2 + 1 = \text{Gray Levels}$$

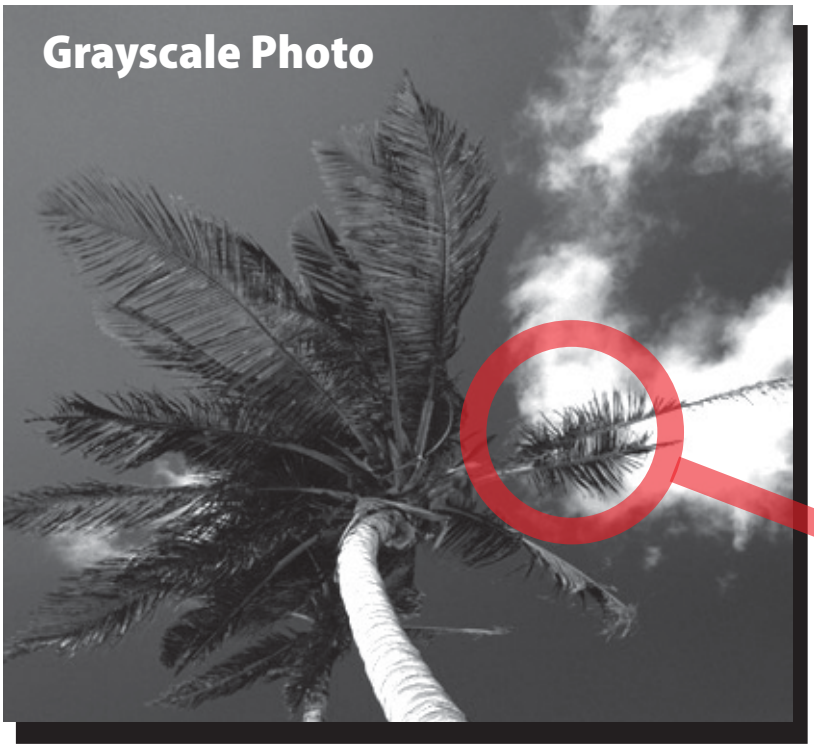
Examples:

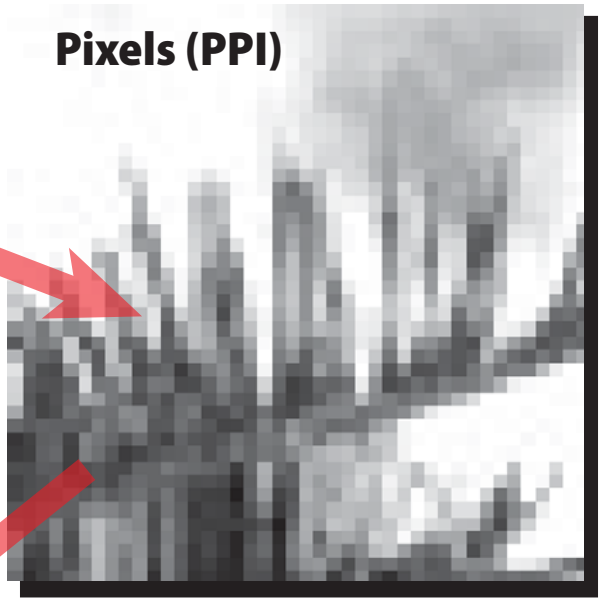
Printing to a 600 dpi printer at 100 lpi gives us 37 gray levels.
Printing to a 1200 dpi printer at 100 lpi gives us 145 gray levels.
Printing to a 2400 dpi printer at 100 lpi gives us 577 gray levels.

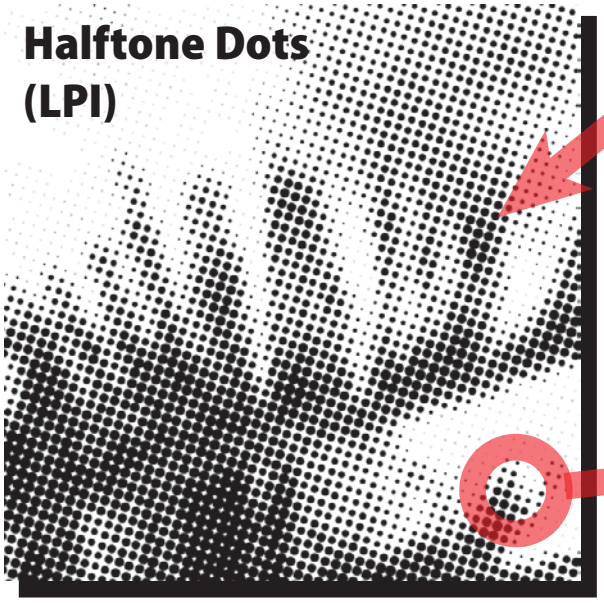
The extra printer resolution makes quite a bit of difference for photographs. For commercial printing, printing to a 2400 DPI imagesetter/platesetter at 150 LPI gives us 257 gray levels. (The human eye usually needs about 200 gray levels for images to look realistic.)

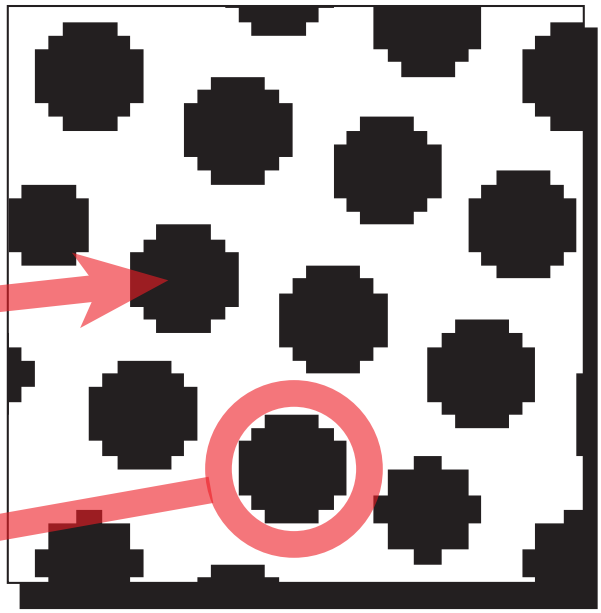
Inkjet printers use a different method of printing that puts down much smaller specs of color of the same size but in various densities (unlike laser printers that print different size dots but in a consistent density). What this means to the user is that they can't go by the inkjet DPI as a method of determining gray levels and image resolution. For practicable purposes, you can assume that a 1400 DPI inkjet printer is equivalent to a 600 DPI laser printer.

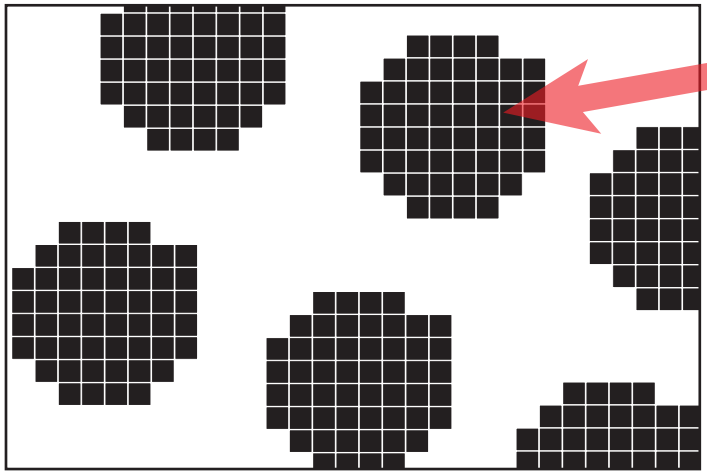
Commercial printing also as a printing method that is similar to inkjet printing, called Stochastic printing (also called frequency modulation (FM) screening). Usually, you can use lower image resolution for Stochastic printing, but you should discuss your resolution requirements with the printer.











Printer dots (DPI)