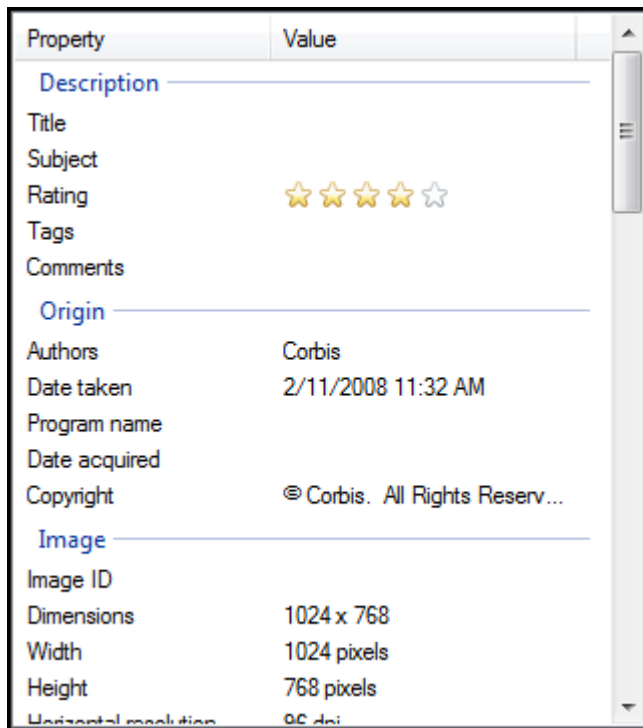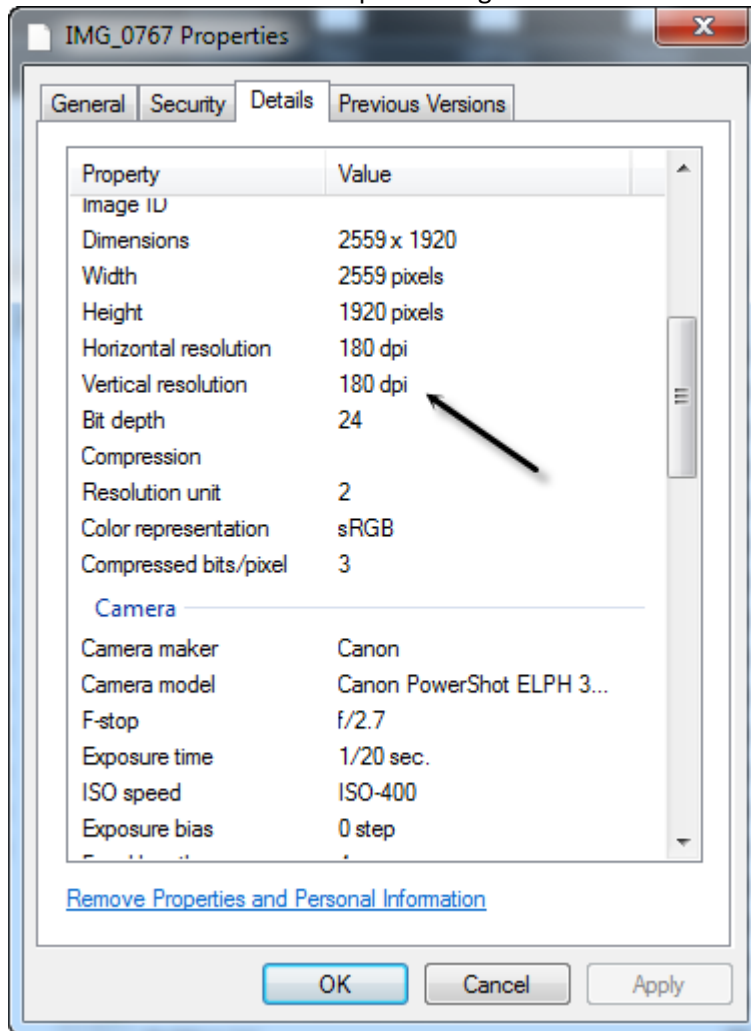# All about resolution

Questions

Let's start with several questions that we should be able to answer after reviewing this document. Answers are at the end.

1. If my camera is a 12-mega pixel camera, what size prints can be obtained from the JPG images?
2. How many mega pixels are required to print an 8" by 10" photo?
3. At what resolution should I scan a 5" by 7" photo in order to make a 5" by 7" print?
4. At what resolution should I scan a 3" by 5" photo to make a 6" by 10" print?
5. At what resolution should I scan a slide in order to make an 8" by 10" print?
6. What's the largest JPG that you should email to someone for viewing on their screen?
7. How can I resize an image disproportionately?
8. What's the difference between resizing and resampling an image?
9. Do you need more pixels to print than you need to view on screen?
10. How many mega pixels do you need to fill a monitor screen?
11. If I right-click a picture and select Properties and get the following window, how large can I print it?

12. What's the difference between PPI (Pixels per Inch) and DPI (Dots per Inch)? See http://www.andrewdaceyphotography.com/articles/dpi/ and http://www.steves-digicams.com/knowledge-center/coming-to-terms-with-dpi-ppi-and-size.html.
13. More questions. See http://www.microscope-microscope.org/imaging/image-resolution.htm.
14. How many dots per inch is my monitor? See - http://whatis.myscreenresolution.com/.

15. What does the number 180 dpi in the figure below mean?

Introduction

The definition of Resolution can be quite confusing, primarily due to the fact that it depends on the context in which the term terminology is used.

In a strict sense, resolution is a measure of how fine an image dots are, by dividing the number of pixels by the physical size (as in "300 dots per inch"). But the exact meaning of that number does change depending on where and how an image is used, and where it is in the input-to-output workflow. Knowing your resolution is important when you're communicating with someone else or a device such as a printer.

There are 2 main classes of devices, input devices including cameras and scanners and output devices including printers and monitors. We usually don't have to worry about our monitors except to make sure you have it set to the highest resolution when working on photos.

- **Camera resolution.** Let's assume that we're using a 12 mega pixel camera. A typical camera of this type captures images that are 4000 pixels wide by 3000 pixels tall. These images have an aspect ratio of 4:3. About all we can say about this device, our camera, is that the files that it generates are 4000 pixels by 3000 pixels. We very seldom have someone ask us "What is the resolution of your camera?" but if they ask, the answer is that it shoots up to 12 megapixels. This is not the complete story but it is

enough for this discussion. Digital cameras write arbitrary Pixels per Inch into the JPG just to put a number in that field. I've seen a number form 72 up to 300.

  o Here's an example from a Canon G15 camera. For the screen shot below I selected Image, Size, Resize in Photoshop Elements. Notice that this camera uses the value 180 PPI for JPG images.
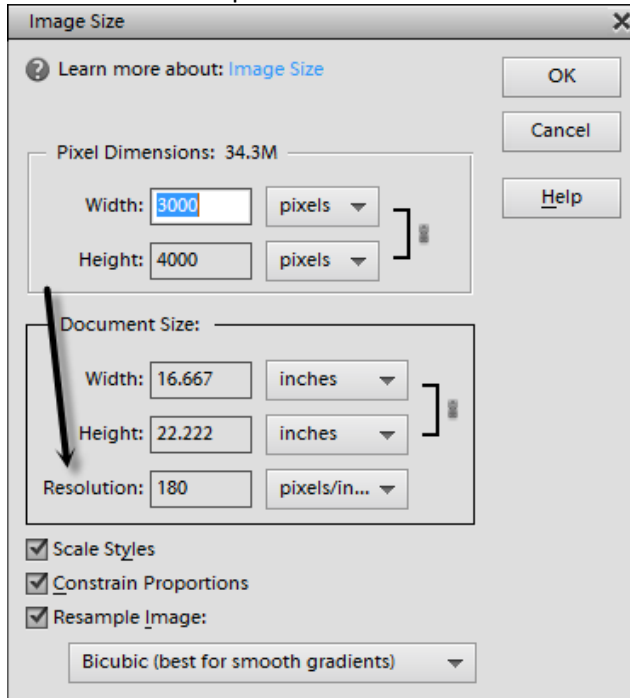
- **Sampling resolution**. If you're using a scanner, this is the resolution at which a scanner samples or scans the original. This number describes, in samples per inch (SPI) or dots per inch (DPI), how precisely an image was scanned. You control sampling resolution using your scanning software. For digital cameras, sampling resolution doesn't really apply: You could be taking a photo of a landscape 3 miles wide or a close-up of a 3-inch-wide flower, making "dots per inch" quite arbitrary.
- **File resolution**. When you save an image from Photoshop Elements or other software, the software writes an image resolution into the file. File resolution doesn't mean much unless you print the image, because it doesn't refer to the number of pixels in the file. This number tells the printer how to lay down the ink. For example, if the image is printed at 72 Pixels per Inch (PPI) the print will be pixelated but if it is printer at 240 PPI it will look good.
- **Device resolution**. This number isn't part of the image at all, but is the resolution of the output device. For example, a monitor might be 96 dpi. My monitor has a resolution of 1920 by 1080 and is 21 inches wide and therefore, has a resolution of 1920/ 21 or 91 Pixels per Inch. For print, an image doesn't need to match the device resolution. For example, you don't need to send a 5,760 PPI image to a 5,760 dpi inkjet! A 360 PPI image prints very well.

Here's another way to look at resolution.

Assume you are scanning a 1-inch square object

1" or 200 dots wide when scanned at 200 dpi

For Printing
1. If scanned at 200 dpi & printed at 200 dpi, output will be 1" by 1"
2. If scanned at 400 dpi & printed at 200 dpi, output will be 2" by 2"
3. If scanned at 200 dpi & printed at 400 dpi, output will be ½" by ½"
4. Must scan at 1600 dpi & print at 200 dpi for output to be 8" by 8". In other words, to enlarge by 8 times, you must scan at 8 times the final output resolution.

What this implies is if you want to print a scanned slide at 240 DPI at a size of 8 inches by 8 inches you would have to scan it at 8 times 240 or approximately 2000 DPI. This means that you should have a scanner that supports 2400 dpi scanning to print 8 inch images.

For viewing on the Screen
1. If scanned at 200 dpi, the output on a screen using a monitor set at 1920 by 1080 will be 1/10 of the screen or 200 pixels wide. The height will be 1/5 of the screen.
2. Must scan at 2000 dpi to completely fill screen width.

Resolution for Printing vs. Emailing

With a camera such as the Nikon Coolpix 885, the image resolution is 2048 by 1536. This means that an image contains 3.14 mega pixels.

When an image is captured by the camera, it is stored as a jpeg, assuming that the tiff mode is off. The jpeg is stored at 72 dpi which means that the picture dimensions, if printed, would be 2048/72 or 28.44" wide by 1536/72 or 21.33" high. This is obviously too large to print and the 72 dpi resolution would provide poor print quality. Therefore, in Photoshop Elements for example, you should change the resolution to 240 PPI prior to printing.

What resolution should be used for printing?

Epson recommends that you use an image resolution of 1/3 of the printer resolution. If the printer has a 720 dpi resolution, then the image should be 720/3 or 240 ppi. If you resize the Nikon image to 240 ppi, it will now be 2048/240 or 8.5" wide by 1536/240 or 6.4 high. Using 200 ppi, the image would print at approximately 10.2" by 7.7" (8 by 10). The 200 ppi image quality is likely to be slightly degraded from the 240 ppi image.

Notice that images are specified in ppi or pixels per inch and printers in dpi or dots per inch since the principles are different. A printer requires several dots to print each pixel which is not true for screen viewing.

Note: If you are using Photoshop Elements you can print most of the time without worrying about the JPG's resolution.

Now - what about viewing on a screen.

If a screen resolution is 1024 by 768, the Nikon image will fill 4 screens since it has twice as many pixels in each direction as the screen. Therefore, an image must be reduced for 2 reasons to be properly viewed or emailed. It has too many pixels and the file size is too large, approximately 1.3 megabytes for a jpeg shot in the "Fine" mode.

Typically, for screen viewing, a good resolution for an image is 1024 wide by 768 high. This will fill most of the current screens.

How do you reduce the file resolution?

First and foremost, always save the original image in a safe place before producing a reduced resolution image for viewing or emailing.

There are several factors that dictate the file size. They include compression, number of colors and the number of pixels. All camera images are in 24-bit color so this can be ignored for this discussion. The number of pixels can be changed by most image editing software using re-sampling.

Re-sampling vs. re-sizing

Re-sampling is the removal or addition of pixels using a software algorithm. This is usually performed to reduce the image size. Re-sizing, on the other hand, does not change any pixels in the image but merely tells the printer, thru software, at which dpi to print the image. If you lower the ppi, then the image size will increase and conversely. There is usually an option to constrain the file size which means you are re-sizing only.

Many software programs have a feature for doing this. It is usually under a menu item labeled Image->Size.

After changing the number of pixels, the file can be further reduced in size by reducing its quality. When a jpeg is saved, there usually is an option for setting the quality or amount of compression. Nikon compresses images by a factor of 4, 8 or 16 depending on the camera settings. When saving a jpeg in your image editor software you can choose between Maximum, Average or Low quality resulting in decreasing file sizes with attendant reduction in image quality. The best setting for you is determined by trial and error and will vary depending on the image content.

Re-cap

Large files are required for printing and smaller files for viewing or email. Small files are achieved thru compression, which is a reduction of pixels and possibly reduction of quality. You usually require two separate images, the original for printing and a reduced file size for emailing. Remember, a tiff shot with the 885 can be up to 9 megabytes but a file suitable for emailing should be no larger than one mega byte. You can convert any tiff to a jpeg in your software prior to re-sampling for email.

Resolution for Scanning Slides

The major problems with scanning a slide are twofold, you require a special light source since light must pass through the slide and second, the slide is a small object. Therefore, to scan slides you need a scanner with two things, a transparency adaptor and fairly high resolution, 2400 DPI or higher. These range in price anywhere from $200 to well over $1000.

For home use, the Epson Perfection V500 ($150) or V600 ($210) scanners with the transparency adaptor are excellent choices.

A 35 mm slide is 36x24 mm, if mounted, is about 1.3 x 0.84 inches, so at 300 dpi, you would get no more than a (300 x 1.3) x (300 x 0.84) = 390x252 pixel image from full frame. And twice that size with a 600 dpi scanner, you get about 780x506 pixels from mounted slides at 600 dpi. That size might be acceptable for web pages or TV, but is not sufficient pixels for printing.

To print an image that is at least 7 inches at 240 dpi requires 240 x 7 or 1680 pixels. With a slide dimension of 1.3 inches, that requires a scanning resolution of 1680/1.3 or approximately 1200 dpi.

To display an image on your screen at least 800 pixels wide requires a scanning resolution of 800/1.3 or approximately 600 dpi.

If you scan 35 mm film at 600 dpi, and print it at say 200 dpi, then the image will be scaled to print at 600/200 = 3 times larger than the original film. If the original was 1.3x0.84 inches of film (full frame), then that is nearly 4 x 2.5 inches printed, less than drugstore photofinisher size. If you tried to print 8x10 inches, then that 780x506 pixel scan prints at about 506 pixels / 8 inches = 62 dpi, less than good. So this size image might be acceptable for a web site, but probably not of much interest for printing on paper. But if our film size were 4x5 inches, the answer is different.

Therefore, you should scan a slide at a minimum of 1200 dpi for an output of 8 x 5 inches or 2400 dpi for larger prints.

Example:
Scanning a 1.3 x .84 inch slide requires a scanning resolution of 2400 DPI to print it as an 8" by 10" print. One way to calculate this is as follows:
- We're blowing this up roughly 10 times.
- To print this at 240 DPI we need to scan at 10 times this number or 2400 DPI.
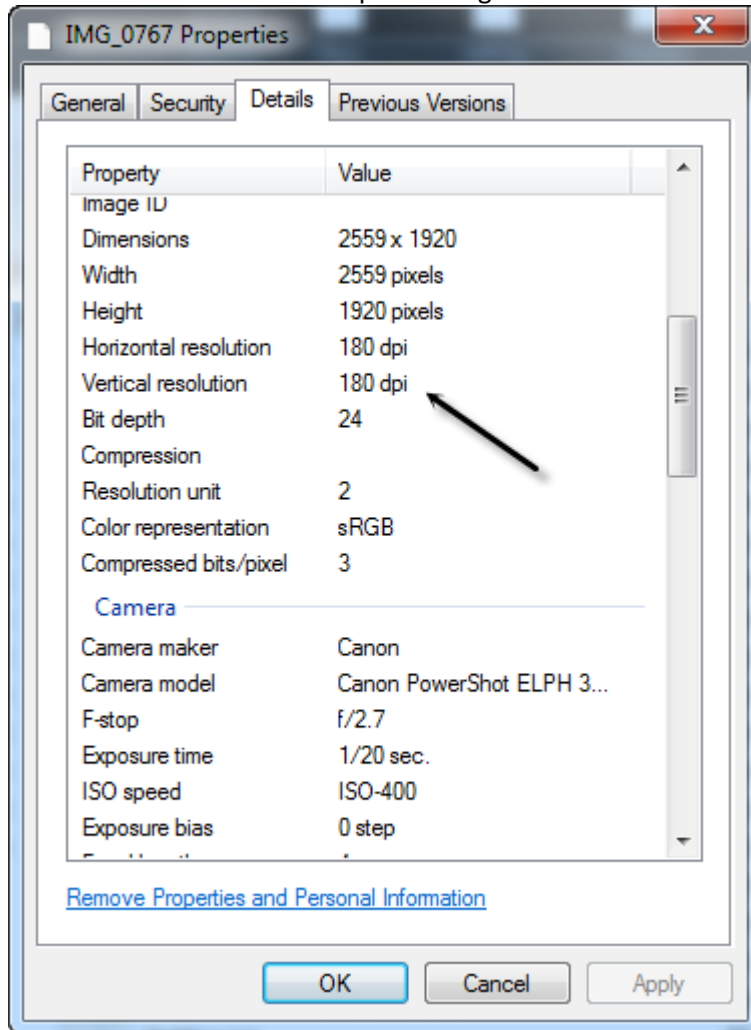
Answers

1. If my camera is a 12-mega pixel camera, what size prints can be obtained from the JPG images?
   - Answer – assuming that a print is made at 240 PPI, the largest print is 12,000,000 divided by 240 divided by 240 which is approximately 200 square inches and possible a 13" by 19" print.
2. How many mega pixels are required to print an 8" by 10" photo?
   - Answer -8 X 10 X 240 X 240 = 4.6 mega pixels.
3. At what resolution should I scan a 5" by 7" photo in order to make a 5" by 7" print?
   - Answer – at 240 DPI.
4. At what resolution should I scan a 3" by 5" photo to make a 6" by 10" print?
   - Answer – at 2 x 240 or 480 DPI
5. At what resolution should I scan a slide in order to make an 8" by 10" print?
   - Answer – approximately 8 X 240 or 2,000 DPI
6. What's the largest JPG that you should email to someone for viewing on their screen?
   - Answer – typically 1024 X 768 or 800 kilo bytes
7. How can I resize an image disproportionately?
   - Answer - See http://www.inspire-soft.net/software/easy-image-modifier for a program that can do this. It is a portable program. This can also be done with Photoshop Elements but not as easily.
8. What's the difference between resizing and resampling an image?
   - Answer – Resizing has absolutely no impact on the number of pixels in an image whereas Resampling either increases or decreases the number of pixels.
9. Do you need more pixels to print than you need to view on screen?
   - Answer – Absolutely. – approximately 5 to 10 times.
10. How many mega pixels do you need to fill a monitor screen?
    - Answer – less than 1 mega pixel
11. If I right-click a picture and select Properties and get the following window, how large can I print it?
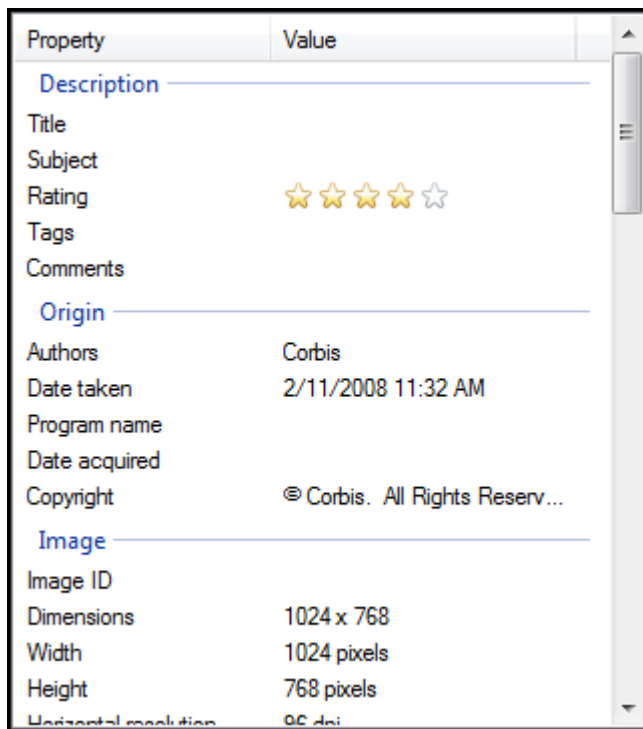
- Answer – roughly 3" by 4"

12. What's the difference between PPI (Pixels per Inch) and DPI (Dots per Inch)?
    o Answer - See http://www.andrewdaceyphotography.com/articles/dpi/ and http://www.steves-digicams.com/knowledge-center/coming-to-terms-with-dpi-ppi-and-size.html.
13. More questions. See http://www.microscope-microscope.org/imaging/image-resolution.htm.
14. How many dots per inch is my monitor? See - http://whatis.myscreenresolution.com/.
    o Answer – My monitor is 1,920 pixels wide and 21" across making the resolution 91.4 PPI.
15. What does the number 180 dpi in the figure below mean?

IMG_0767 Properties

| General | Security | Details | Previous Versions |

Property	Value
Image ID	
Dimensions	2559 x 1920
Width	2559 pixels
Height	1920 pixels
Horizontal resolution	180 dpi
Vertical resolution	180 dpi
Bit depth	24
Compression	
Resolution unit	2
Color representation	sRGB
Compressed bits/pixel	3

Camera

Camera maker	Canon
Camera model	Canon PowerShot ELPH 3...
F-stop	f/2.7
Exposure time	1/20 sec.
ISO speed	ISO-400
Exposure bias	0 step

Remove Properties and Personal Information

OK   Cancel   Apply

    o Answer – it doesn't mean anything. This is an arbitrary number.