

A Tutorial on Resolution

Want Some Wallpaper?

Where was my head last month? I had totally intended to set up the final version of the image used in [last month's tutorial](#)¹ as a full-sized image and offer it as a desktop wallpaper image. My bad. My penance will be to [offer it this month](#)² at enough resolution to natively fill a 30" Apple Cinema Display. Bon appétit.

Tiny Little Dots

Time to get on with it. This month, I hope to clear up the confusion many have with the concept of resolution. Even if I had ten hands, I would not have enough fingers to count the number of times I've been sent a low resolution photo that is intended to go in print from a person who claims it is large enough. "It's full size on my screen, so it should be large enough," they might say.

Wrong answer.

As we'll explore this month, the resolution of your monitor is far lower than the resolution generally printed on paper. Even if you're fortunate enough to be using a 30" Cinema Display, an image that fills the entire display is most certainly not suitable for a 30" print. In fact, I'll demonstrate why this size of an image is actually only suitable for something in the neighborhood of a 9"×6" print. Yes, still very large, but not as large as your display. This is compounded further by the fact that most everyone from whom I received some version of the quote above was probably using a 1024×768 monitor—a resolution *barely adequate* for a 4"×3" print! A little bigger than 3"×2" is all I'd really plan on at that resolution.

What Is Resolution?

I'll start with an image that is 1,600 pixels wide and 1,200 pixels tall. This is a size setting you might commonly find on a digital camera. Seems like a lot of pixels, doesn't it. Exactly how big would this shot be on paper?

¹<http://www.atpm.com/13.07/photoshop.shtml>

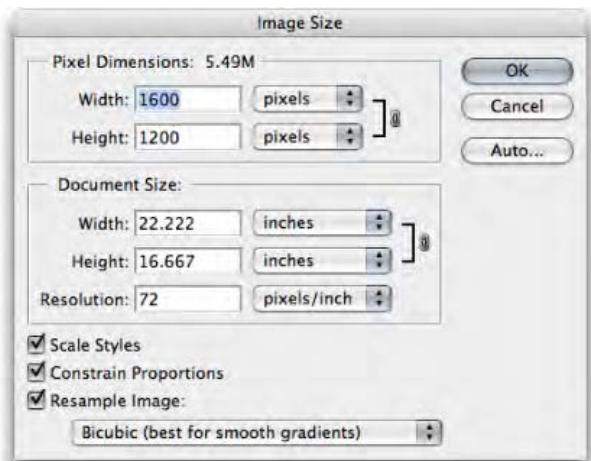
²<http://www.atpm.com/13.08/images/ATPM-Wallpaper.jpg>

First, what does the 1600×1200 mean? Well, there's a reason why "sixteen hundred by twelve hundred" can be represented as 1600×1200—because the "×" also means you can multiply the numbers. If you do the math, you get 1,920,000. In other words, a 1600×1200 image is a little less than two million total pixels—or a 2 megapixel camera. Suddenly, 1600×1200 doesn't seem so big any more, does it?

Regardless whether you refer to 1600×1200 or 2 megapixel, you're talking about the total number of pixels in an image. But this, alone, is not enough to definitively say how big the image will print. Note that I said earlier that 1600×1200 "seems like a lot of pixels" and not "seems like a lot of resolution." The total number of pixels in an image *is not* its resolution.

Here's the surprise: our image can be *any* resolution and remain 1600×1200! Resolution has nothing to do with the total number of pixels in an image and everything to do with how large or small the pixels are represented. In other words, resolution specifies the amount of linear space a certain number of pixels should occupy.

Now would be a good time for a visual. I have a photo open that is 1600×1200 pixels in size. I'll head to Photoshop's Image menu and select Image Size.



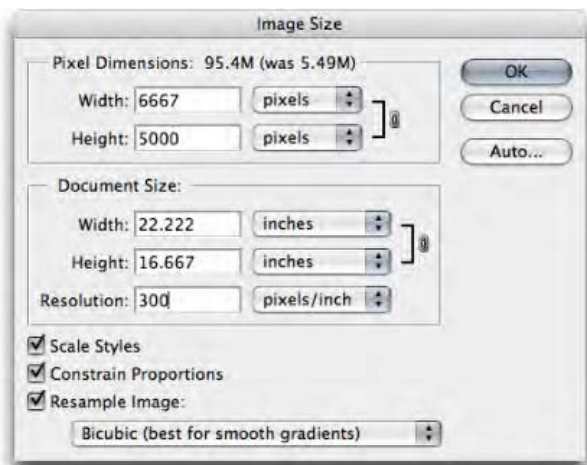
Photoshop's Image Size menu.

In the Pixel Dimensions section, we see confirmation that my image is 1600×1200 pixels. But what’s that in the Document Size section? More than 22 by 16 inches? Can a 2 megapixel camera really print that big?

Well, yes and no. Look at the third setting in the Document Size section. The Resolution is set for 72 pixels per inch. This number makes all the difference in specifying the size of your image, and setting it correctly depending on the final destination of your image is key.

I said above that an image’s resolution defines how many pixels occupy a certain amount of space. Time for some more math. An image’s Document Size is calculated simply as the Pixel Dimensions divided by the Resolution. In this case, 1,600 divided by 72 equals 22.222, and 1,200 divided by 72 equals 16.667.

What’s happening is, we’re specifying that 72 pixels should fit in exactly one inch of space. So let’s see what happens if we change the Resolution value.



6667×5000 pixels? What happened?

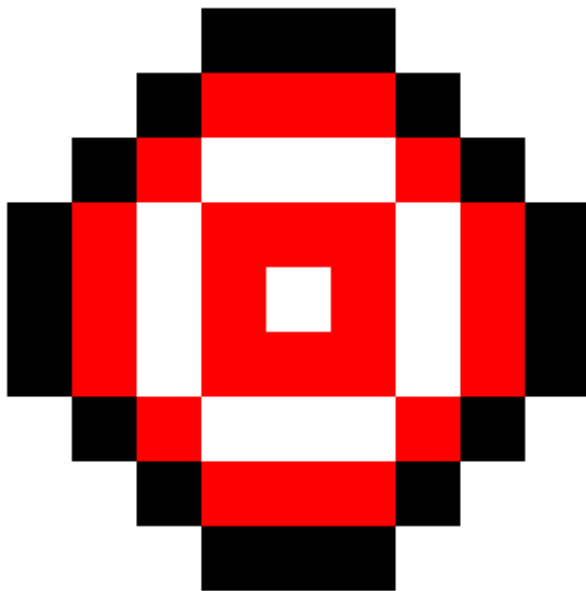
In this screen shot, the Resolution has been changed to 300. The Document Size is still 22.222×16.667 inches, but look at the Pixel Dimensions. That can’t be right, can it?

What happened is that the current settings in the Image Size menu locked the Document Size and resized the image (the Pixel Dimensions) to accommodate the changes. In this case, the image has been enlarged by almost 425%. Enlarged? But the Document Size is still the same!

Not exactly. Yes, the width and height are the same, but look at the resolution. We’re now at 300

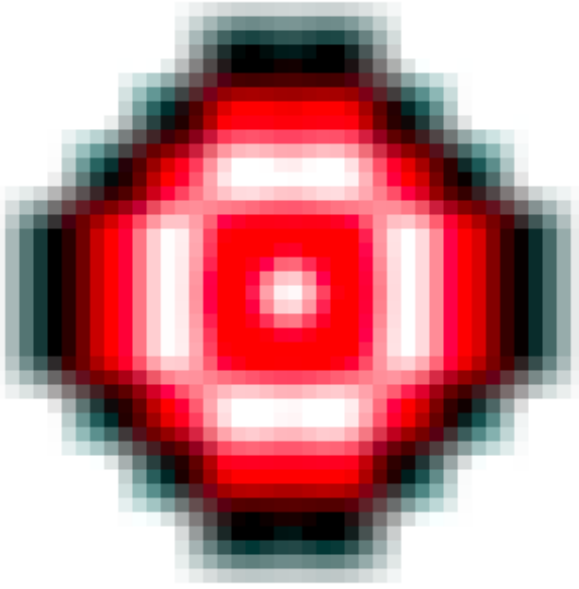
pixels per inch. By increasing the resolution while also keeping the Document Size the same, Photoshop has had to add a lot more pixels to the image to account for the fact that we told it to put 300 pixels in every inch instead of only 72. This is represented by the increase from 1600×1200 to 6667×5000.

So where do those pixels come from? In simple terms, Photoshop invents them. Seriously. You’ve been told before, haven’t you, that it’s bad to enlarge a digital photo? This is the reason why. In order to fill up the extra pixels, Photoshop has looked at all the neighboring pixels and has guessed, based on math, what additional pixels are needed. If you enlarge an image exactly 200%, you now have four pixels for every original one. However, it doesn’t mean you’ve now got four pixels worth of detail that previously only had one. Rather, it means that one pixel has been blown up to the space of four pixels. Time for another visual.



The individual pixels at 72 pixels per inch.

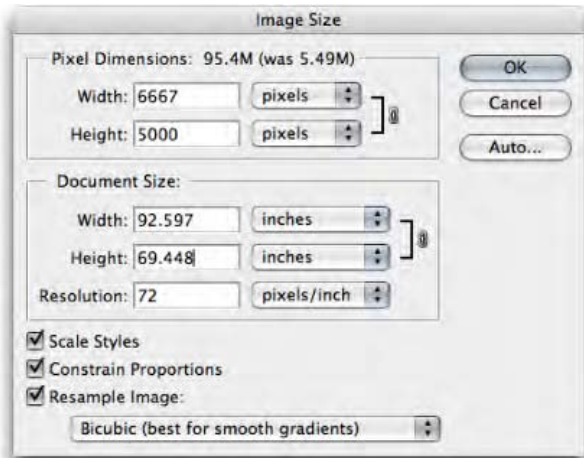
The above screen shot is zoomed in to look at the individual pixels of a sample image. Each square block (such as the white block in the exact center) represents a single pixel. Now let’s see what happened when the Resolution was changed to 300 and the Pixel Dimensions increased to 6667×5000.



The same image, enlarged.

The same basic shape is visible, but Photoshop has attempted to smooth it out by guessing what additional pixels were needed to make up the difference. Instead of just a single pixel for the white spot in the center, that spot is now represented in approximately 20 pixels (four wide and five tall). You can see the smaller squares throughout the image. We've made it higher resolution, but we've also made it very blurry and pixelated.

The same problem would happen if you left the Resolution at 72 pixels per inch, but increased the Document Size values.



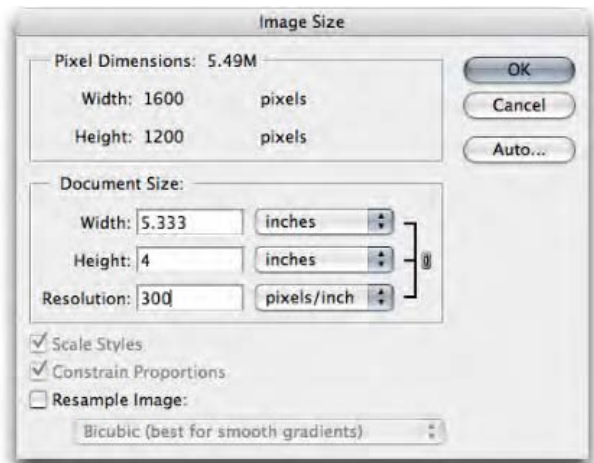
Still 6667×5000, but at 72 pixels per inch, we're up to more than 92 inches wide!

How To Change Resolution With Pleasing Results

It takes just two steps to adjust an image's resolution in a way that doesn't cause these problems, while simultaneously revealing how large you can print your image on paper.

The first step is the really easy part. Simply uncheck the Resample Image checkbox. When you do this, you'll notice that you can no longer adjust the Pixel Dimensions and that the black lines on the right side of the Document Size section have expanded to point to Width, Height, and Resolution (the previously only pointed to Width and Height, assuming the Constrain Proportions checkbox was on). This means those three items are now linked. If you change any value, the others will automatically update to compensate for your change.

Let's see what happens when we change the Resolution to 300 this time.



More realistic for printing.

With the Resample Image checkbox turned off, the Pixel Dimensions remain at 1600×1200. This means we are in no way damaging the available information in the original image. When not resampling, you can adjust the Document Size as much as your whim desires, and nothing will harm the image.

Notice, however, the Width and Height values when the Resolution is changed to 300. They're now showing 5.333 inches wide and 4 inches tall. Using the same math as above, we discover that 1,600 divided by 300 equals 5.333 and 1,200 divided by 300 equals 4.

Alternatively, you can specify that you want the image to be only three inches wide. Entering a Width

of 3 automatically changes the Height to follow proportionately at 2.25 inches, and you have a resolution of 533.333 pixels per inch. The smaller the Document Size, the more Resolution when resampling is turned off.

You'll remember, at the beginning of this month's column, I said I would demonstrate that the resolution of a 30" Cinema Display is only suitable for a much smaller print. If the Pixel Dimensions are 2560×1600 (the dimensions of the 30" Cinema Display), the Document Size is 35.556 inches wide and 22.222 inches tall at 72 pixels per inch. But, at 300 pixels per inch, the same Pixel Dimensions only give 8.533 inches of width and 5.333 inches of height.

And this brings us to step two. How do you know what value the Resolution should be, and why have I been talking about 72 and 300 pixels per inch up to this point?

In general, consumer-level digital cameras and most computer displays work at 72 pixels per inch, but this is beginning to change. Many semi-professional and nearly every professional digital SLR camera specifies its images at 300 pixels per inch. Remember, as we've seen above, you can change the resolution of an image without changing the total number of pixels. In other words, 6 megapixel is still 6 megapixel regardless whether you've defined it as 72 or 300 pixels per inch.

In addition, many computer displays are also working at a tighter, more detailed resolution—often 96 or more. You probably heard how Apple boasted about the iPhone being 160 pixels per inch. This makes for a much more crisp display of graphics than most standard computer monitors working at 72 pixels per inch.

There's a very good reason why 72 pixels per inch is something of a baseline, but it would take another long article to fully explain it. Suffice to say that 72 pixels per inch matches perfectly with graphic design measurements set in place long before computers came around—measurements which define 72 points as equal to one inch. Yes, that absolutely does mean that six lines of 12 point type should fit in one inch of height. Well, that doesn't account for something called leading, but let's not bother with that.

The other resolution value I've been using, 300, is slightly arbitrary, but is used because it's a nice, even number to use as a reference point. It turns out that when a digital device prints a photo on paper, your eye shouldn't be able to discern the tiny pixels if 300 of them are squeezed into one inch. In reality,

depending on the type of printer or press being used, you can often get away with less resolution. Most people can't see pixelation even at 200 pixels per inch. Not that I want to brag, but in high quality glossy inkjet prints, 200 pixels per inch is about where I'm just able to detect slight pixelation. But, of course, I know what to look for.

So, by doing the math, and assuming you have a 3.1 megapixel camera that produces images that are 2,048 pixels wide and 1,536 pixels tall (3,145,728 total pixels) at 300 pixels per inch, you're good for a print that is 6.8 inches wide and 5.1 inches tall. Of course, a photo lab technician would probably tell you that a 3 megapixel camera is perfectly fine for an 8×10 print. Well, at 200 pixels per inch, they'd be right, and you'd probably be perfectly happy with the quality. But for best results, you're better off assuming 300 pixels per inch.

DPI or PPI?

I suppose 300 pixels per inch is something of a magical number for photo resolution. A lot lower and you begin to see blurry pixelation. Conversely, a lot higher is sort of a waste. You might be thinking that if you have a 6 megapixel camera (10.25 inches by 6.8 inches at 300 pixels per inch), you could ramp up to 600 pixels per inch for a super detailed 5×3 inch photo. In some ways, you'd be right, especially when you consider that inkjet printers these days are running 1200 DPI and higher.

Wait, what's that? What is "DPI"?

Aha, young grasshopper. You've entered the realm of dots per inch!

Let's get a very small, but very important, fact straightened out right now. Dots per inch (DPI) is not the same thing as pixels per inch (PPI). You may only just now realize that I never once in this article prior to this paragraph mentioned DPI. Common misconception will suggest the two as meaning the same. As we've covered above, pixels per inch refers to the individual single spots of color that make up an image. Dots per inch, on the other hand refers to ink on paper. You'll generally find that the available DPI of a printer is far higher than the PPI needed for a pleasing image.

We've already established that 300 PPI is a bit more than sufficient (but an easy number to work with that isn't too much overkill) for printing images, even if the printer is capable of a DPI that is higher. In other words, the PPI of an image *does not* have to match the DPI of your printer. Having the extra DPI

resolution on a printer is a benefit for graphic images (not necessarily photos) with extremely fine detail—much finer than needed for a photograph. Even many typefaces with ornate serifs and flourishes look a lot better. Most people can easily see the difference in quality of standard Times New Roman on a 300 DPI printer and a 600 DPI printer.

So, Do I Really Need More Than 3 Megapixels in a Digital Camera?

Knowing now that a 3 or 4 megapixel camera is completely adequate for typically sized photo prints, why would anyone need more megapixels?

The answer for most people is—you don't need more. But when I say "most people," I'm talking about those who don't do anything to their photos other than take them to a photo lab. They're content with a print that, more or less, matches the framing they originally shot with the camera.

However, if you're someone who likes to shoot a little wider just to make sure you don't miss something, and then crop your photo later, this is where having the extra pixels are a benefit.

To illustrate, let's start with a photo of a [USSOCOM paratrooper](http://www.atpm.com/13.05/airfest/USSOCOM.shtm1)³ from last May's desktop photos. Suppose you took this shot with a 3 megapixel camera and you want to make a print cropped close to the paratrooper. Let's see what happens when we crop and enlarge just the paratrooper to a 4×6 inch shot and look at it on the computer screen.



Enlargement from a 3 megapixel camera.

Remember, 300 pixels (one inch in print) is obviously going to display much larger on a 72 PPI computer display. I've also taken the above screen shot with the image showing at 400% actual size so you can see the pixel resolution. It's very blocky.

But now, here's a sample of what the exact same shot would look like if it were cropped the exact same size, but had been taken with a 6 megapixel camera instead.

³<http://www.atpm.com/13.05/airfest/USSOCOM.shtm1>



Enlargement from a 6 megapixel camera.

Once again, I'm looking at this image at 400% size, so you're still going to see pixelation in this sample. But notice now that within the confines of my screenshot, the paratrooper is now larger and more pixels are being used. You can make out more details in this version.

The point of showing this is to say that while you'll probably never see any difference between uncropped images out of a 3 and 6 megapixel camera, you will notice a lot more flexibility if you crop your photos.

It can't be stated more simply than this: cropping a 6 megapixel photo in half will give you a 3 megapixel photo, and cropping a 3 megapixel photo in half will give you a 1.5 megapixel photo. Get it?

Coming Back to Photoshop

I know I've spent a good deal of space talking about digital cameras instead of Photoshop, but hopefully you see the correlation. A key thing you should've noticed in the Image Size window is that as long as the Resample option is turned off, it actually makes absolutely no difference what the Resolution setting is. As a desktop publisher, I regularly redefine 72 PPI photos as 300 PPI. I even have a preset action in Photoshop to do it.

What matters to me is the Pixel Dimensions. Anything bigger than 1600×1200 I know is going to work fine for me. Likewise, anything from a 2 or 3

megapixel camera up to 6 or higher is going to be fine for you.

Much smaller, however, and print reproductions begin suffering.

Web Photos

I'll wrap up by coming full circle on the hypothetical quote at the beginning of this column, "It's full size on my screen, so it should be large enough." Much to the annoyance of graphic designers, clients will frequently ask a designer to use this or that photo from a Web site, mistakenly believing it will print just fine. Again, wrong answer.

Take the earlier example of the USSOCOM paratrooper. I had access to the original, full-size digital image for the above examples, but the [thumbnail page](#)⁴ that I first linked shows the image at only 420×279 pixels. No joke, there are clients who'll actually send a shot this size for use in print publication.

Do the math. 420×279 at 300 PPI is roughly one and a third inches wide by not even one inch tall!

Further Discussion

I realize this is a very heavy subject and that I may not have done it justice. If you're still scratching your head over this, I strongly encourage you to [ask questions](#)⁵. For me, this is the type of subject that I can do far better at answer questions than at giving a blanket explanation—though I do hope this article has been of some value to you.

Topics For Upcoming Months

- Creating Seamless Tiles
- Mask-erades
- Fun With the Automate Menu
 - Photomerge
- Fun With Filters
- File Format Fever

If you have a topic suggestion, please [share it](#)⁶. I'm definitely interested in expanding this list with topics that are of interest to you.

⁴<http://www.atpm.com/13.05/airfest/USSOCOM.shtml>

⁵[http://www.atpm.com/13.08/photoshop.shtml#comment](http://www.atpm.com/13.08/photoshop.shtml#comments)s

⁶[http://www.atpm.com/13.08/photoshop.shtml#comment](http://www.atpm.com/13.08/photoshop.shtml#comments)s