Research Imaging Solutions

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imaging essentials

raster, bitmap, photo & vectors
defined

resolution, physical dimensions,
color mode & file format
explained

Research Imaging Solutions
RIS@hms.harvard.edu
it.med.harvard.edu/ris

Beth Beighlie
Digital Imaging Coordinator
Research Imaging Solutions
Information Technology Department
Harvard Medical School
220 Longwood Avenue
Boston, MA 02115
(617) 432-2323
b2@hms.harvard.edu

Written by Beth Beighlie

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Imaging Essentials

Basic Imaging Concepts

Images Defined

Raster Images

The first types of image files we'll discuss are pixel-based images, which include photo, bitmap and any pixel-based image. These terms, raster, photo, bitmap and pixel-based images, are interchangeable. They all refer to images that are composed of a grid of pixels.

File formats for photo, raster and bitmap images include: .JPG, .TIF, .GIF, .PSD, .BMP, .PICT, .JPG2, .PNG, and any scanned image that hasn't been OCR (optical character recognition) processed. Put a bunch of individual pixels together and when viewed as a whole, they'll represent an image. The quality of raster images is described in terms of resolution.

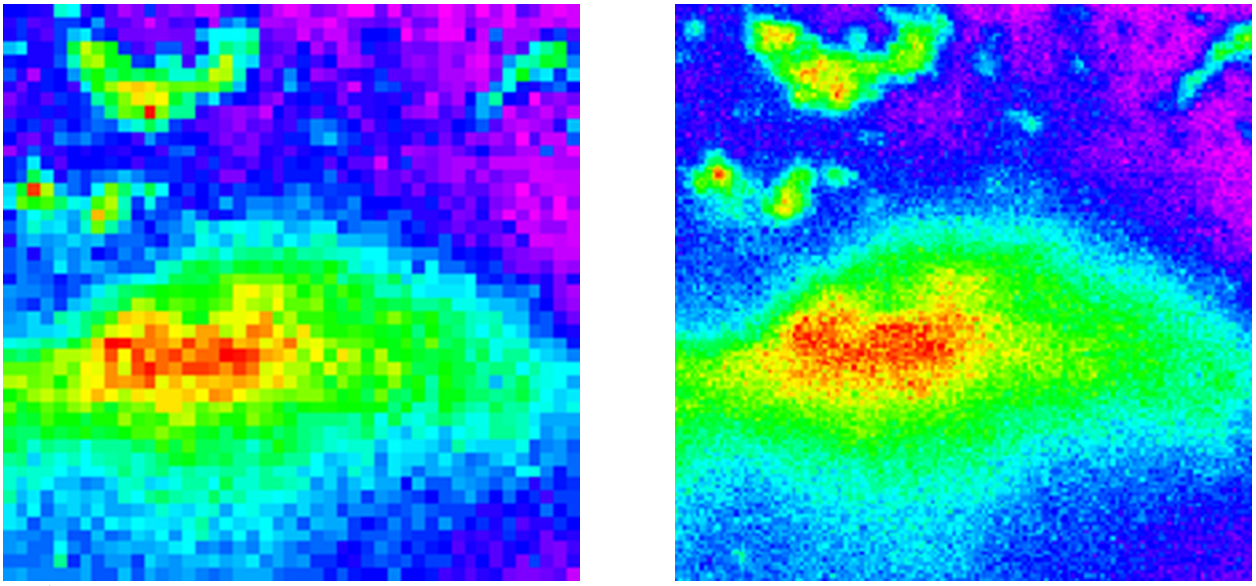


figure 1 *The raster image on the left demonstrates how low resolution images make the pixels more visible. The image on the left also illustrates what can happen if improperly resizing raster images.*

Resolution can be either dots per inch (dpi), or pixels per inch (ppi). The higher the resolution, (the more pixels or dots per inch), the higher the quality and the better their representation will be, but only up to the extent of the output device's ability to display it. For example, viewing images on a monitor with a screen resolution of 72 dpi, the limiting factor is the 72 dpi resolution. When viewing two different resolution versions of the same image on a monitor, one at 600 dpi, and the other at 72 dpi, they will appear to have the same 72 dpi resolution, as determined by the resolution of the monitor, but the larger file will require more time to open.

Without a pixel-based image editing application (like Photoshop or the free, open source GIMP), photo, raster and bitmap images cannot be reliably resized for higher resolution or larger physical dimension.

Trying to resize these types of images to a larger physical dimension by grabbing and dragging one of it's selection edges will seriously diminish the quality of the image. The most obvious problem would be that the pixels would become more visible or that the image would appear to blur. For this reason, to modify the resolution or physical dimension of a photo, raster or bitmap image, it is necessary to use a pixel-based image editing application like Photoshop or GIMP. Resizing images within PowerPoint or Word is unreliable and will usually yield poor quality images.

Vector Objects

The second type of image files discussed are vector images or objects which are drawn by a mathematical algorithm that defines points and curves rather than pixels. Vector objects are scalable and not resolution dependent; because there are no pixels, there is no resolution to speak of. Resize them to any degree and they will always display and print beautifully. To change the size of vector objects, simply select the object (it may be necessary to ungroup the elements) and use the selection handles to drag and resize. Do not use a pixel-based image editing application like Photoshop or GIMP. Doing so would rasterize the image and significantly degrade image quality by eliminating the smooth line properties of vector objects.

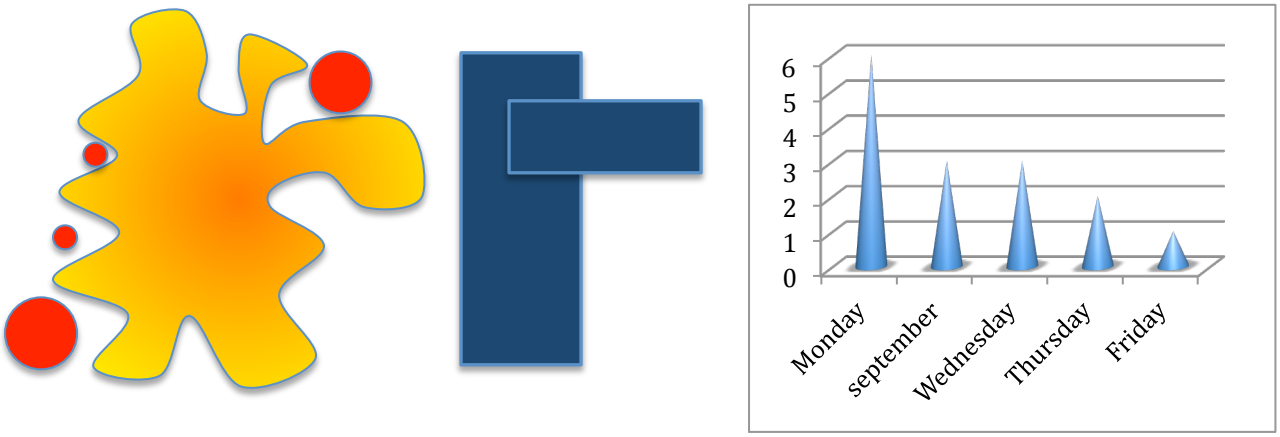


figure 2 *Text, tables, charts and shapes drawn with drawing tools are examples of vectors. Because there are no pixels, vectors print and display the crisp, high contrast edges of these objects much better than raster file formats.*

Vector objects can include text elements as well as any shape, illustration, cartoon or line art that has been drawn using the drawing tools in Microsoft Office products (PowerPoint, Word, Excel), Adobe Illustrator or Deneba Canvas. There are many proprietary scientific applications that generate vector objects. In terms of scientific figures, the most common type of vector created are charts and graphs that are generated by data sets. Excel is very good at creating vector objects that are generated from numerical data. Common file formats that support vector objects include: .PDF, .EPS, .PS, .AI, .FH, .SWF and .PPT. Note that I say '*support*' vectors. Many of the file formats that are capable of displaying vectors, can also contain rasters.

Vectors that are Rasterized

Many vector-capable file formats (.PDF, .EPS, .PS, .AI, .FH, .SWF and .PPT) can contain pixel-based objects as well as vector objects. Think of .PDF documents: .PDF files contain vectors (text, annotation, line art, charts, graphs) but they can also contain rasters, in the form of photographs, micrographs and other pixel- based images.

However, pixel-based file formats (.JPG, .TIF, .GIF, .PSD, .BMP, .PICT, .JPG2, .PNG, and any scanned image that hasn't been OCR processed) will only contain pixels.

figure 3 *Saving anything that contains text, tables, charts or objects created with a drawing tool as a raster file (.JPG, .TIF, .GIF, .PSD, .BMP) will degrade the quality of the image by blurring curved lines and high-contrast edges.*

Saving a file that contains vector objects in any photo, bitmap, raster or pixel-based file format is rarely a good idea. Doing so will cause any vector objects to rasterize and lose all of the sharpness and high contrast edges of the vector object. Rasterizing a vector file will transform the crisp-looking lines and curves into pixels and that will give text, annotation and artwork a blurry appearance. It is precisely this reason that when submitting figures for publication, sending the journal a .JPG, .PNG, .TIF or other raster format is a bad idea. Further, if you need to resize the resulting raster object, the image will now require the use of a pixel-based image editing application like Photoshop or GIMP. The only justification for rasterizing a vector is if someone is unable to open a vector- and this should never be the case, since the any file can be saved as a .PDF and anyone can download the free Acrobat Reader (for instructions on how to save a PDF from a PowerPoint figure, see *Output Options* handout at it.med.harvard.edu/ris).

Once an object has been converted to a pixel-based file format from a vector-capable format, it cannot be easily converted back to a vector-capable file format. The vector attributes will be lost.

The process of scanning illustrations, cartoons or text makes them raster images, not vector images. When scanning these types of images, scan at a higher resolution than one would typically scan photo-only images. These high resolutions scans can then be 'dumbed down' to a size that is appropriate for whatever your output requirements are.

Photos, Raster, Bitmap, Vectors…what do I care?

Trust me you do. Given the choice, keep your vector objects as vectors. Don't save them as any raster file format unless there is a specific reason to do so.

If submission guidelines suggest that figures be submitted as raster file format (.TIF, .JPG, .PNG or .GIF) OR a vector file format (.PS, .EPS, or .PDF) AND if your figure has any vectors (charts, tables, text, arrows, shapes drawn with Drawing Toolbars) you should choose a vector file format for best results.

If your figure has vector objects (charts, tables, text, arrows, shapes drawn with Drawing Toolbars) and .EPS, .PS or .PDF file types are not an option for submission, and therefore you must submit a pixel-based file format, .TIF and .PNG are better bitmap choices because they rasterize vectors better than .JPG. (for instructions on how to save figures as different kinds of file types, see the *Output Options* handout at it.med.harvard.edu/ris)

The best way to do this is to use the right application for creating your figures. PowerPoint files are an excellent solution for handling both photo images and vector objects in the same figure. If you correctly prepare your pixel-based images in Photoshop (with the correct resolution [see Resolution chart], physical dimension [don't resize images once inserted into PowerPoint] and file format [.JPG, .PNG or .TIF]) and insert them into PowerPoint you can annotate (add text, arrows, highlighting circles, etc.) in a way that will guarantee a high quality figure with sharp looking text, high contrast edges and curved lines.

Unless you are confident about your ability to save a .PSD file to the required format for a journal in a way that will maintain the integrity of your vector elements, don't use Photoshop to annotate. Photoshop is a raster-based application and when saving figures as a .JPG, .TIFF or .PNG file it will rasterize text and annotation so it looks pixilated (see figure 3). Use Photoshop to edit your images only, then insert them into PowerPoint to annotate.

Image Type Chart

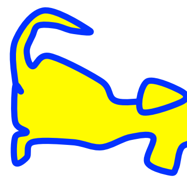
Object type	Characteristics	Examples	Usual file types	Editing & insertion method
Raster objects 	•Pixel based •Described in terms of resolution (dpi) •aka bitmap •Cannot grab object & stretch to resize larger	•Photographs •All images from Scanners Microscopes cameras •All .tif, .jpg, .png & .gif files	•.tif •.jpg •.png •.gif	•Photoshop •Insert >Picture From File
Vector objects 	•No pixels / no resolution •Mathematical algorithm •OK to grab object & stretch to resize larger	•Illustrations •Text objects •Drawing tool objects •Tables, charts & graphs •Never .tif, .jpg, .png or .gif file type	•.eps •.ps •.pdf •.ppt, .ai, .cnv	•Either the application it was created in or Office (ungroup) •Never Photoshop •Paste Special
Rasters that were vectors 	•Pixel based •Described in dpi •aka bitmap •Cannot grab object & stretch to resize larger • blurry	•Scanned Illustrations •Illustrations that have been 'rasterized' •All .tif, .jpg & .gif files	Often • .tif .jpg • .png .gif Occasionally • .eps	•Photoshop •Insert > Picture From File

figure 4

Raster File Formats:
How To Handle Them And Get The Best Results

When it comes to editing pixel-based images, it is crucial that you work on *copies* of your master file, and to edit in the editing software's proprietary format, i.e., .PSD for Photoshop editing, or .CNV for Canvas editing. After completing the image editing process, do a "Save As…" and save the edited image to the file format that is most appropriate for however the image will be used. .PNG, .JPG and flattened .TIFF are the best file format choice for creating figures within PowerPoint. When editing a complex image, (if it contains layers, or has been expanded to more than an 8-bit image, etc.), save it as a .PSD version, so further adjustments can be made to the file in the future. PSD and .TIFF support layers, while .JPG does not. If using PowerPoint to build a figure and you wish to include a .TIFF file, you should not use any additional compression options (i.e.: LZW)

Rasters: Practical Considerations

What considerations?

If you have upgraded your digital camera to a higher megapixel sized sensor, you have no doubt discovered that the higher the resolution, the larger the file size is. High-resolution images = a larger file size = greater pixel dimensions = higher quality and better appearance of the image when using high resolution output devices. Sort of. As discussed, the target resolution of the image is really determined by the output device. As I explained, while a 600 ppi image is a higher quality image when compared to a 72 dpi file of the same image, if both are displayed on a monitor that is 72 dpi, you will see no difference in the quality. A 72 dpi display can only show images at 72 dpi, regardless of the resolution of the image file it is displaying. And while the images will look identical to each other, you may notice that the higher resolution file might take longer to load.

One size does NOT fit all

Determining the proper resolution for an image file is a little bit of a balancing act. You want the best quality image possible, and to that end, you should start with a high-resolution *copy* of the master file and reduce it down to the resolution requirements of the output device or the submission requirements for a publication.

While it's true that higher resolution images of scientific data are generally better for both quantization and some forms of presentation than lower resolution images, this leads to large files that may not be appropriate for certain modes of display. You must balance the demands of displaying a detailed scientific image file, in terms of file formats and size, with these practical considerations. Generally speaking, high-resolution images are appropriate for quantization and analysis. Those same images can be reduced to a much lower resolution for display in presentations, posters and papers.

Image Size And Resolution

Speed and Reliability

With today's computers we have increasing speed and capacity working in our favor. Don't let this fool you- it is still important to edit images to a target file size, resolution and physical dimension that is most appropriate for each particular output device. There is additional incentive for making images only as large as they need to be when you consider that while capacity and speed of computers have increased, applications, such as PowerPoint, still have limitations and difficulty displaying unnecessarily large or high resolution image files. Overly large images may not display at all, or may display a big red "X".

Netiquette

It's always a good idea to have large, high-resolution master files stored safely somewhere, perhaps on a central server that is regularly backed up. Do not directly edit any master files.

- ***Work locally***: When editing images, first, save a copy to your local hard-drive. Do not work on images opened directly from the server over the network. Not only will the editing process be slower over a network, but also it slows it down for all users. What's more, you run the risk of corrupting your file as you edit.
- ***Smaller is better***: When emailing image files, especially if the recipient will only be viewing it on their monitor, send images that have a pixel dimension that doesn't exceed 640 x 480. The smaller physical dimension will ensure the recipient will be able to see the entire image on their monitor without having to scroll or resize. Another compelling consideration is data transmission speed. While many users have given up the slowness of a modem and dial-up connections, not all internet connections are the same. Many workplaces do have fast connections, but private homes may not enjoy that luxury.
- ***Play nice in the sandbox***: Send only medium resolution (125 dpi for images without rasterized vectors; 225 dpi if there are rasterized vectors) images to networked printers. Higher resolution images will not yield a better print and will create a logjam, delaying all print jobs that are sent to the printer after yours.

Resolution, Physical Dimension, Pixel Dimension, File Size

Pixel Dimension vs. DPI

Pixel dimension is the actual size of the image file- it describes how many pixels the image has horizontally and how many pixels it has vertically. The larger the numbers, the bigger the image can be printed and the larger the file size.

DPI/PPI

These terms pertain to the output capabilities of an image file. For the most part, they can be used interchangeably. Dots Per Inch, or DPI is mostly associated with printing to paper and Pixels Per Inch, or PPI is a term used to describe how a computer monitor might display an image.

Even though the most accurate way to gauge an image file is consider it's pixel dimension, convention has us wedded to the concept of resolution, so we must pay close attention to the relationship between physical dimension and resolution if we want to know how an image will display or print.

resolution	physical dimension	pixel dimension	file size
72 dpi (i.e.: LCD projection)	10 x 7.5	720 x 540	1.1 M
200 dpi (i.e.: laser printers)	10 x 7.5	2000 x 1500	8.6
300 dpi (i.e.: photo quality printers)	10 x 7.5	3000 x 2250	19.3 M

figure 5 *One way to determine the resolution of an image is to divide the pixel dimension by the physical dimension. For instance, if the pixel dimension of an image's width is 1800 and the physical dimension of the width, in inches is 6, the resolution is 300 dpi.*

Bit Depth (Color Depth)

Bit depth specifies the number of precise shades or colors that an image can potentially have. Images that have a greater bit depth have many more shades (of gray, if in a grayscale image file) or colors (if RGB) than images with a lower bit depth. It is important to remember that bit depth refers to *potential* shades or colors- it does not mean that each shade or color is actually represented within the image.

8-bit or 24-Bit, which is it?
What gets confusing at times is that while we speak of an 8-bit RGB image, we're usually really talking about a file that consists of 3 color channels and therefore it can, occasionally, also be referred to as a 24-bit image (3 color channels, with 8-bits each). Generally, if you open such a file using Photoshop, you will see that Photoshop calls it an 8-bit RGB image, even though it has a total of 24-bits (3 color channels, with 8-bits each). An 8-bit RGB image is capable of generating 16,777,216 colors.

On the other hand, an 8-bit grayscale image is capable of displaying 256 shades of gray, the darkest being black and the lightest being white. Since that 8-bit grayscale image has only one 'color' channel, that 8-bit grayscale image really can be called 8-bit, without any confusion.

When considering file size, as it relates to pixel dimension and resolution for a raster image, the larger files size inherent in greater bit depth doesn't necessarily create a better looking image. The human eye can only perceive around 10 million colors. It is for this reason that 8-bit RGB images are more than adequate to create a figure for display, whether you use a monitor, data projector, poster printer, desktop printer or journal. Higher bit depths are only necessary in some cases for image quantification and analysis. 32-bit images are useful when creating high dynamic range images (HDR). Most digital cameras create files at 8- or 16-bit.

Bit Depth Chart

Bits per pixel (bpp)	Number of colors or shades available per channel
1	2
2	4
4	16
8	256
16	65536
24	16777216
32	16777216 + transparency
48	281 Trillion

figure 6 *Bit depth refers to potential shades or colors- it does not mean that each shade or color is actually represented within the image.*

Determining target resolution, dimension, color mode and file type for rasters

Do it before you start preparing figures!

The first consideration is to determine which device or devices you are going to use for output. Ideally you want to prepare an image in Photoshop that is the correct resolution, physical dimension, bit depth, file format and color mode for your needs. You want to avoid resizing or editing the image in any application but one intended for editing pixel-based images, like Photoshop or GIMP. ***Do not resize or otherwise edit images using PowerPoint***. If you require several output needs, acquire or prepare the raster image for the highest output resolution then "Save As…" different versions for each different output need.

For grants, abstracts, papers and journal submissions
If you are preparing figures for a grant, a paper for a journal or for inclusion in a poster or publication, refer to their submission guidelines to determine what resolution and physical dimension is required.

For LCD projectors, laser and inkjet printers
Each output device has different resolution and physical dimension requirements. To determine these numbers look at the *Resolution Chart* within this article. (see figure 7)

For all figures
If you plan to build a figure using one or more raster images, with or without vector objects, PowerPoint is a good choice for assembling these elements. Remember that you will still need to use Photoshop to make edits to any raster images. For the ambitious figure-builder, Adobe Illustrator is the ideal application to create composite figures. However, the learning curve and lack of compatibility of Illustrator with the Microsoft Office suite makes PowerPoint a more efficient tool, especially since journal-ready files can be generated with PowerPoint. Instructions for generating different file types from PowerPoint can be found in the *Creating Figures* document at it.med.harvard.edu/ris

To determine the resolution, refer to the *Resolution Chart* (see figure 7) in this document. If you require a step-by-step recipe on creating figures, including how to determine physical dimension, see *Creating Figures* handout at it.med.harvard.edu/ris.

Generally, your workflow will be to edit raster images with Photoshop, then assemble the figure and annotate in PowerPoint.

Output Devices: Resolution And Physical Dimension Targets

The following is a guide of resolution requirements of different devices. It's best to acquire images at a higher resolution (i.e.: 400 dpi for photo, bitmap or raster images and 1200 dpi for line art, illustrations, cartoons and text) and save that as your master image and make lower resolution iterations according to how you'll be outputting it. Don't overwrite your master images with your "reduced size" versions!

In terms of displaying images, it is important for users to understand that what they have worked hard to make look good on their systems won't be displaying or printing for other users in quite the same way. Most of the problem lies in the fact that output devices, including monitors, are not often calibrated. This introduces a lot of variables as to how an image actually appears. Another consideration is the fact that Macs and PCs display things differently: PCs generally display everything slightly darker.

With regards to output, higher resolution doesn't mean better looking: The quality of your image is only as good as your output device. For example, data projectors output at roughly 72-96 dpi. The quality of the image that is projected will not improve no matter how many pixels per inch the image file is, it will only project at 72-96 dpi. In fact, if you do try to project a high-resolution image, you run the risk of hogging so much memory that you (at worst) hang the application or (at best) cause the projected image to draw extremely slowly on the screen.

NOTE: If you need to change the resolution or physical dimension of your image, it is important that you use a pixel-based image-editing application like Photoshop or GIMP and take care to properly resize the image.

Super high-quality photographic printers
These very high quality printers will output a glossy photo-like image for journal submission.

> Photo-quality inkjet printers with glossy paper
> Physical Dimension of printable area: dependent on manufacturers specs
> 180-360 dpi for photo images, bitmap images and raster images (with no scanned text or line art within). Many Epson printers print at about 360 dpi- some Epsons will only print at 320.
> 360-600 dpi for scanned or rasterized line art, illustrations, vector objects and cartoons.

High-quality plain paper printers
These high quality printers are great for creating drafts for proofing image edits, outputting multiple copies for in-house handouts or review and making images that don't require the more costly photo-quality images. The resolution for plain-paper printers is not as high as it is with photo-quality printers. A resolution of 125-150 dpi is sufficient. If your image file has rasterized text or vector objects, you may find better results with higher resolutions of up to 600 dpi. Run a test print to see if you really do need to have such a large image file since printing at that higher resolution will slow down the process.

> **Laser printers**
> Physical Dimension of printable area: as low as 8" x 9"
> 125-225 dpi for photo images, bitmap images and raster images (with no scanned text or line art within).
> 300-600 dpi for scanned or rasterized line art, illustrations, vector objects and cartoons.

Presentations

When creating your slides in PowerPoint, if you plan to use a computer and a LCD projector to display your presentation, check that the slide size in the Page Setup Dialog Box is set as On-Screen Presentation. Images prepared for data projectors are usually displayed using PowerPoint or Keynote. While PowerPoint can be used on both Macs and PCs, Keynote is a Mac only program. You can safely use pixel-based images (that contain no rasterized text or vector objects within) as low a resolution of 72 dpi for insertion into on-screen presentation applications that will be shown using a LCD data projector. Unless you have an image that when tested doesn't give you the detail you need, don't go higher than 100 dpi for photo-only images. If you insert many images that are higher than 100 dpi there is risk that the presentation will slow down to an unacceptable rate or worse- fail to open or run entirely. If you have time and access to a data projector, run a test to see if you really do need to have such a large image file. Also, you must test your On-Screen presentation on the computer and projector that you will be using if you are to expect your presentation to go off without a hitch.

LCD data projection

Physical Dimension of PowerPoint On-Screen Presentation: 7.5" x 10"

100 dpi for photo images, bitmap images and raster images (with no scanned text or line art within).

200 dpi for scanned or rasterized line art, illustrations, vector objects and cartoons.

Poster printing

Physical Dimension: size posters according to the submission guidelines provided by the meeting organizers.

For correct resolution requirements, check with poster printing service bureau, but usually it's in the neighborhood of 125-200 dpi for photo images, bitmap images and raster images (with no scanned text or line art within) and at least 300 dpi for scanned or rasterized line art, illustrations, vector objects and cartoons.

If you have created your poster with PowerPoint and will be printing your poster at 100% of it's size, the above resolutions will work well. If you are printing at 200% of it's size, you must double the resolution of any inserted pixel-based images.

Outside publication or printer

If you are preparing an image for a particular publication or an outside publisher, contact that publication or printer for submission guidelines to determine what resolution, color mode and file type they want you to provide.

Again, One size does NOT fit all

It can not be stressed enough: even if you understand that higher-resolution files have the potential to generate better quality images, it is foolish to use the highest resolution file for all output devices. Doing so will invite unexpected results and not guarantee the best-looking image. It is also important to know that if you want a higher resolution image, simply increasing the resolution in the Image Size dialog box is not the way to achieve that goal.

Resolution Chart

The following is a guide for the output resolution requirements of different devices. It is advisable to acquire images at a higher resolution (i.e.: 400 dpi for photo, bitmap or raster images and 600-1200 dpi for line art, illustrations, cartoons and text) and save that as your master image and make lower resolution iterations according to how you'll be outputting it. Sorry, one 'size' doesn't fit all- you will need different sized images for different output needs. Be careful! Don't overwrite your master images with your 'dumbed down' versions!

Art Work Type / **Output Device**	**Photo Images Bitmap Images Raster Images (with no text or vector objects within)**	**Raster images that contain Line Art Illustrations Vector Objects Cartoons Text**
PowerPoint On-screen Presentation LCD Data Projector Computer Monitor/Display Web Site *Physical Dimension of PowerPoint On-Screen Presentation: 7.5" x 10" otherwise physical dimension of projector or monitor = pixel dimension of device*	100 dpi	200 dpi
Laser Printer (LaserJets & LaserWriters) *Printable Area varies*	125-225 dpi	300-600 dpi
Photo- Quality Inkjet *Printable Area varies*	150 dpi (plain paper) 180 or 240 or 320 dpi (photo paper)	300-600 dpi
Photo-Quality Printer (i.e.: Fujix, dye sublimation printers) *Printable Area = 8" x 10.5" or 8" x 5"*	300-400 dpi (usually 320 dpi)	600-1200 dpi
Poster Printer *Printable Area =determined by service bureau*	125-225 dpi start at 125dpi	300 dpi

figure 7 *If you are scanning 35mm slides or negatives, you should scan at a high enough resolution (at least 1200 dpi at 100%) to be able to resize to a larger physical dimension. Follow the instructions in this document how to properly enlarge the image.*

This resolution chart is to be used as an approximate guide only- there are more precise numbers that can be applied for specific uses. If you'd like to know these specific calculations, use these numbers as starting points and experiment. The goal should be to have a relatively high-resolution master image from which you prepare a file that is the correct resolution, physical dimension and file format for a particular output device. This is especially important when prepping images for insertion into PowerPoint: **DO NOT use PowerPoint to resize your images once you have inserted them.**

File Formats

A word about compression
Unless raster images are saved in a proprietary file format like an acquisition device's native format, .PSD or .CNV, it is likely a choice must be made regarding file compression. For the purposes of quantification and analysis It is preferable that master image files be saved at a high resolution or large pixel dimension and in an uncompressed format, but any image that is shared and most images that are prepared for presentation and display will need some compression. Generally, a good workflow will involve working on *copies* of uncompressed master files, doing all the edits in the uncompressed file format, and as the last step, saving it as a compressed file that is suitable for the particular needs of your display, output or submission guidelines.

Lossy compression is a formula that reduces file size by eliminating data within the raster file, (.JPG, .GIF, etc.). Depending on the level of compression used, this loss is generally imperceptible to the eye, and therefore it may be acceptable to reduce files sizes used for scientific communication by this method. Care must be taken, because data is lost each time a file with lossy compression is resaved. Repeated compression can cause these file types to lose so much information that the image will suffer in quality and begin to look bad, and what's worse, the file may not open due to over compression.

It is for this reason that it is best to work on uncompressed versions of files and as the final step, save them in a compressed file format like .JPG. If this is not possible, choosing Highest Quality is the correct choice when resaving .JPG files. The versatility of .JPG compression makes it a popular file format option, (especially for use on the internet). Because it can be viewed on all operating systems and with many applications, it is the safest bet when sharing files. .JPG file compression also is a good option because it allows the user to determine the level of compression to apply to the file, unlike other compression formats. This flexibility makes it easy to create very small files.

Lossless compression is another algorithm used to compress image files for storage (.TIF, .PNG, etc.), which does not eliminate any data from the file. Lossless file compression produces a larger file than lossy because all of the data is maintained. Therefore, image files that are compressed with a lossless formula, tend to display fine detail and large areas of solid color more reliably.

It is always better to edit copies of uncompressed master files, if that is not possible, editing a lossless compression file format may be an acceptable option. Repeatedly recompressing files with a lossless formula doesn't introduce the inherent risks that repeatedly saving lossy files do.

Raster file formats (aka bitmap images or pixel-based images)

JPG

.JPG is a lossy compression file format that can greatly reduce your file sizes.

The pros: .JPG files are the most versatile file format: it is cross-platform (read by Macs and PCs) and can be opened by and inserted in many common applications. This format also has variable compression that can be set when saving the file.

The cons: Because it is a lossy compression process, the more a file is compressed, more information is lost and has to be filled in by best-guess algorithms when reopening the file. When saving an image in this format, the amount of compression should be experimented with to determine how much the file can be compressed and still appear satisfactorily. .JPG images can be compressed up to 20 fold without unacceptable degradation to the image, but after that, you run the risk of not being able to open the image due to lack of data. .JPG does not support layers

TIFF

.TIF is a lossless compression file format that moderately reduces file sizes.

The pros: .TIF files are nearly as versatile as .JPG files. These files are also cross-platform and readable by many common applications. Because the compression algorithm is lossless, the quality of the image is somewhat better, and therefore is the file type of choice if you have rasterized vectors or very demanding images.

The cons: Because the compression algorithm is lossless, the size of the image file is larger than .JPG files.

Pro or con?: .TIF files can support layers- while this is good for future editing of images, .TIF files that contain layers cannot be inserted into older versions of Office applications like PowerPoint and Word.

PNG

.PNG is a lossless compression file format that moderately reduces file sizes. It is extremely versatile: it is a good cross-platform player and will work well within nearly all applications. One of the best features of .PNG images is that unlike .TIF or .JPG image files, .PNG supports transparency. You can place irregularly shaped objects within applications like PowerPoint and not have the annoying white background show up if you have a dark background on the slide

GIF

.GIF is a lossless image format, which has a different compression scheme that maintains the appearance of borders between colors and lines better than the .JPG format. .GIF is the better of the two formats for rasterized graphic illustrations, cartoons and line (chart and drawing) images. .GIF files support transparency and animation. The transparency feature allows background in the image to be transparent instead of white and allows the image to be placed over other images or content with the other content still appearing through the .GIF image. Animation allows multiple .GIF images to be place in a single file and automatically viewed in rapid succession.

Graphic images for web pages

Rapid-opening graphic image file formats and small file size are critical performance parameters for use of images in web pages. .JPG and .GIF file formats are the most common formats used for web pages. Both formats are compressed and optimized for rapid opening within web and graphics browsers. The format selected should be chosen dependent on the content of the image to be presented.

File Format Chart

Recommended for images containing pixel-based objects, photos, bitmap, raster and rasterized vectors		
Joint Photographic Experts Group	**.JPG**	• Widely used: cross-platform and can be opened by most graphics programs • Best for photos (without text or former vectors) used on web & in email • Lossy compression algorithm • Smaller file size and lesser image quality than .TIF • Best choice for inserting into Word, PowerPoint and Acrobat • Single page document
Ping or .PNG	**.PNG**	• Widely used: cross-platform and can be opened by most graphics programs • Best for photos (that contain rasterized text or vectors) • Lossless compression algorithm • Good choice for inserting into Word, PowerPoint and Acrobat • Supports transparency • Single page document
Tag Image File Format	**.TIF** **.TIFF**	• Widely used: cross-platform and can be opened by most graphics programs • Best for photos (with text or rasterized vectors) • Lossless compression algorithm • Good choice for inserting into Word, PowerPoint and Acrobat • Supports layers • Single page document
Graphics Interchange Format	**.GIF**	• Widely used bitmap format with compression • Limited to 256 colors • Can be animated and supports transparency • Preferred for illustrations and graphics used on web

figure 8a

Recommended for images containing vector objects		
Portable Document Format	**.PDF**	• Widely used: can be opened with free Reader download • Preferred for retaining formatting of shared documents • Preferred for distribution on web & in email • Supports bitmap and vector objects in same document • Supports multiple page documents • not recommended for editing
Encapsulated PostScript & PostScript	**.EPS .PS**	• Printer language • Supports bitmap and vector objects in same document • not recommended for editing
Flash File Format	**.SWF**	• Supports animation, audio and interactivity • Supports bitmap and vector objects in same document
PowerPoint	**.PPT**	• Supports bitmap and vector objects in same document • Supports multiple page documents

figure 8b

Proprietary formats		
Photoshop	**.PSD**	• Lossless bitmap format • Supports layers • Single page documents
Illustrator	**.AI**	• Editable postscript format • Supports bitmap, vector, and text data • Supports layers • Single page documents
Canvas	**.CNV**	• Lossless format supports bitmap and vector data • Layered or multiple pages per file

figure 8c

Color Mode

What to do:
Got color? Make it RGB…;
Not color? Make it Grayscale…;

Generally speaking, if you plan to print to laser or inkjet printers, RGB color mode is the best choice. If you are preparing images to go to an outside publisher or print house, review their submission guidelines to determine the resolution, color mode and file format they want you to provide.

Again, RGB is the color mode of choice. There is no need to work within the CMYK color space unless images are prepared for prepress on an offset ink press. Changing an image between RGB and CMYK should be avoided if possible: there are losses in the RGB/CMYK conversion processes, particularly in the bright colors. Our laser and inkjet printers are designed to print RGB images. The devices printer driver converts RGB to CMYK ink, and uses dithering (stochastic with error diffusion) to produce the required color combinations from the three ink colors.

RGB images
Ideal for color photographs
These are images made with a red/green/blue process. Eight-bit RGB files have roughly 16 million-colors available. Keep in mind that this is a fairly memory intensive mode to work in - a full-page color image can take up to about 40MB! If you are working with a rasterized line drawing, it is best to use the Indexed color mode instead (see below).

Grayscale images
Ideal for monochrome images.
This color mode has a color palette of 256 shades of gray, and is therefore file sizes are significantly smaller than RGB color mode. A black and white or continuous tone image should be stored in Grayscale image mode. Since the file sizes tend to be one-third the size of RGB, grayscale images are a fairly economical way to store images. Grayscale is the correct color mode for radiographs and blots.

Indexed color images

Often the choice for images on websites.

The colors in these images come from a color look-up table.

In order to conserve file size, a color line drawing can be stored in Indexed Color mode (this has a much smaller color palette [approximately 256 colors - can vary] than RGB). If you need to do any image editing to your image, however, you will need to work with it in RGB mode and then change it to Indexed Color upon completion. Do not change an image file back and forth between Color Modes: work in RGB, and after all editing is completed, save it in the Indexed Color Mode as one of your last tasks.

CMYK

Publisher's choice.

Only use CMYK color mode if the publication or printer specifically requests it. Four-color process printing is best set up using the CMYK mode. It is best not to switch images back and forth between modes since they store color information differently and information is changed and may be lost by repeatedly switching modes. Gamut is defined as the range of colors that can be displayed or printed by a given color mode; RGB and CMYK have different gamuts and if you change between modes you may see error messages stating that your image has colors in its palette that are out of gamut. This usually means that a color (or colors) displayed on your monitor cannot be reproduced when the image is printed.

Color Mode Chart

Art Work Type / Output	Color photos	illustrations, cartoons, anything without photos	Black and white or grayscale photos, illustrations, raster and vector images
Internet/ Web/ Computer Monitor/ LCD Projector	RGB	Indexed Color or RGB	Grayscale
Laser Printers			
Inkjet Printers			
Fujix Pictrograph			
Journals, posters	Check submission guidelines (might be CMYK)		

figure 9

Preparing Raster Images for Insertion into Figures

The goal is to create an image that has the correct resolution and physical dimension, so that once the image is inserted it into PowerPoint, it only needs to be positioned and annotated. Do not resize or otherwise make image edits once the image has been inserted into PowerPoint.

Using the *Resolution Chart* (see figure 7) or the submission guidelines, find the target resolution and physical dimension for all raster images. Also identify other requirements like file type, color mode. In most cases .PNG .JPG or flattened .TIF file types and RGB or Grayscale color modes are appropriate.

Edit a copy of raster (pixel-based) image with Photoshop to meet resolution, physical dimension, file type, color mode, etc. needs. Flattening the image is the final step before inserting them into PowerPoint.

Resizing Raster Images

A word about Photoshop's Image Size dialog box

There are several ways to resize images, depending on the size and resolution of the original file and the goals of the image adjustments. Each case will respond differently depending on what options are selected when resizing. For the most part, the instructions outlined below will yield good results. The Image Size dialog box can more finely adjust the resampling algorithm depending on what choices are made in the resampling pull-down menu.

Some resizing options may prove more preferable than others. Some options may have unwanted effects. For example, if the screen capture shown below were resized and resampled using *Nearest Neighbor*, to preserve the hard edges of the text, the resulting image looks terrible. In spite of *Nearest Neighbor* being the recommended option, *Bicubic Sharper* is a better choice for this particular file.

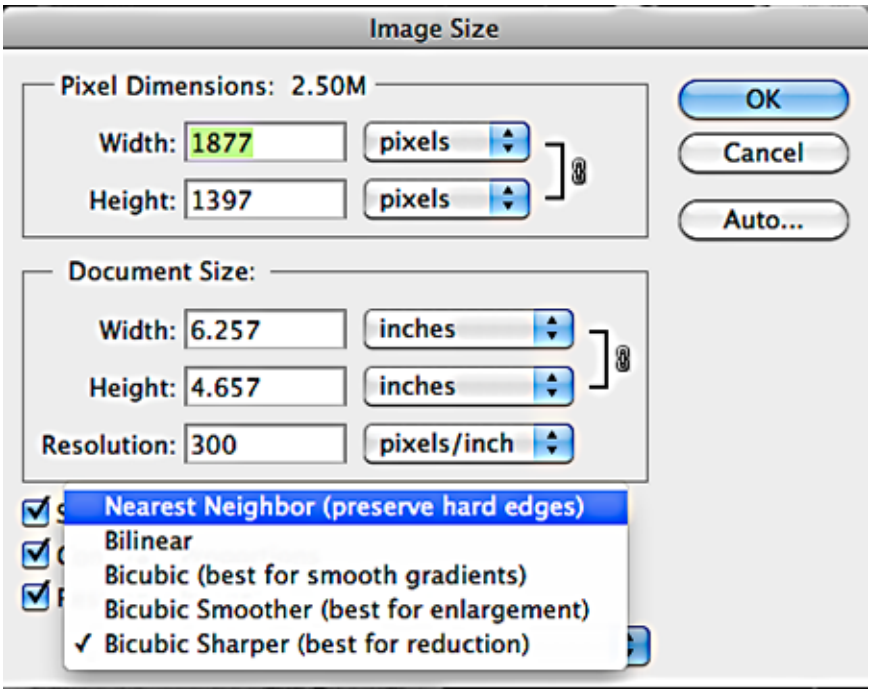


figure 10 *Just because a feature is available, doesn't mean it should be used. The image size dialog box implies that an image can be enlarged by resampling and choosing Bicubic Smoothing. The results might be satisfactory, but if not, use the following instructions for enlarging without resampling.*

Reducing The Resolution Or Physical Dimension (Resizing By Resampling)

Use this if you have a large image and need to reduce the resolution or size only. Do not use this if the image also needs an increase in physical dimension or resolution- resizing by robbing Peter is the option to use.

A. In Photoshop, open the Image Size dialog box from the Menu Bar: Image>Image Size...
B. In the Document Size section of the dialog box, choose the units that you are most comfortable with (pixels, inches, cm, points, etc.).
C. Make sure the 'Constrain Proportions' and the 'Resample Image' boxes that are at the bottom of the dialog box are checked.
D. In the Document Size section, reduce the document's Width or Height. Change only one dimension. Since the proportions are constrained the other dimension will be automatically calculated.
E. Also in the Document Size area, reduce the Resolution according to the target resolution output (refer to the submission guidelines or the resolution requirements for the output device.)
F. Click 'OK'

NOTE: When reducing the image size or resolution there is no loss in quality.
Increasing the image size or resolution will diminish the quality of the image if it's not done correctly. If an image needs an increase in resolution or physical dimension, it is recommended that it be rescanned at a higher resolution and/or dimension, or resize the image according to the following suggestions:

Increasing Resolution Or Physical Dimension (Resizing By Robbing Peter)

Increasing the resolution or physical dimension of a pixel-based image should be avoided. If an image must have an increased resolution or physical size and a higher quality image isn't available, then here is a possible solution: Photoshop is capable of doing the calculation that will increase either the physical dimension or the resolution.

To do either of the following, there must be an excess of either resolution or physical dimension, because this process will be appropriating those excesses to the other dimensions.

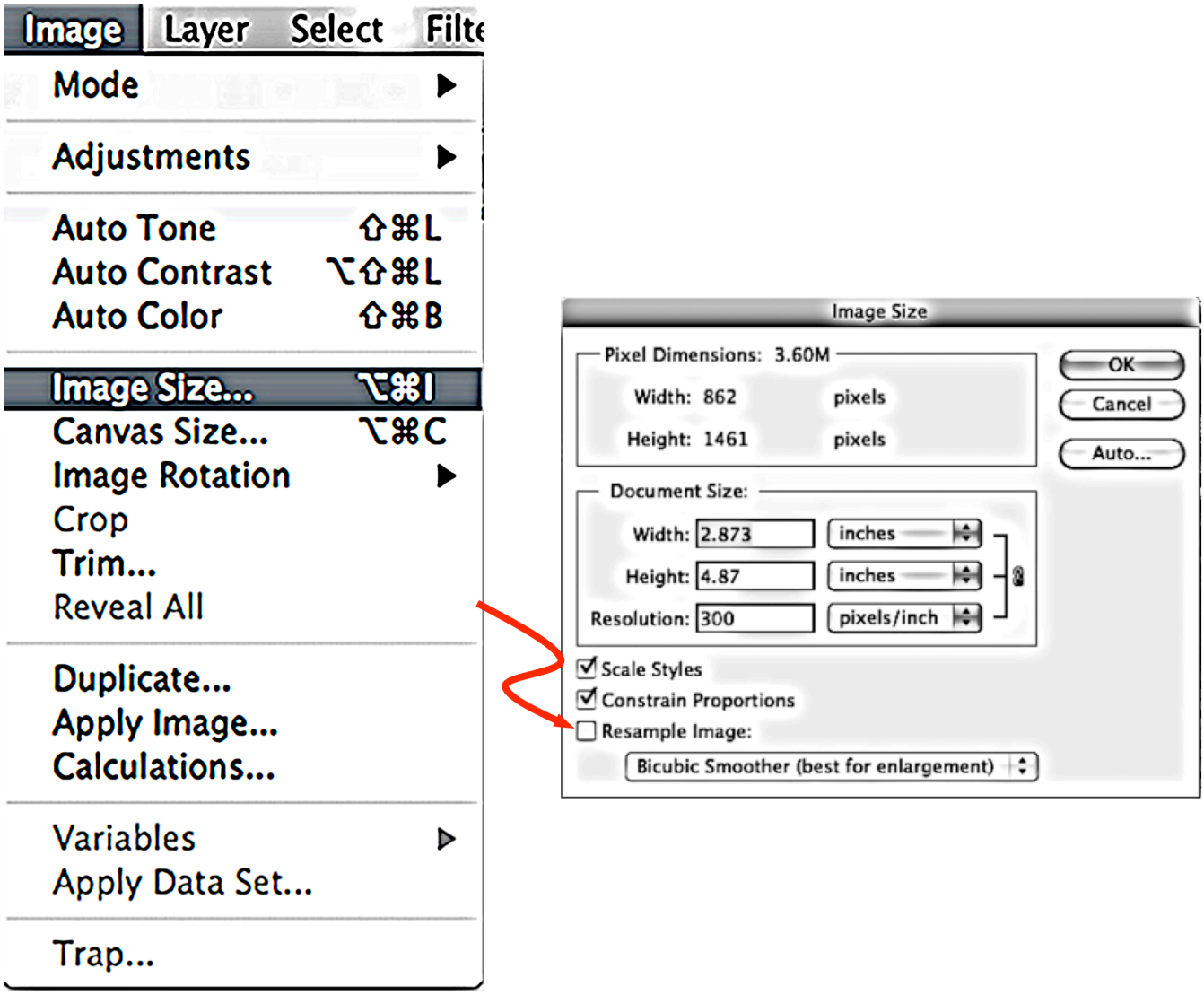


figure 11 *Increasing the Width, Height or Resolution with the Resample Image box unchecked will result in the calculated decrease of the other two dimensions.*

Increasing the physical dimension on small-dimensioned, high-resolution images (which will reduce the resolution):

A. In Photoshop, open the Image Size dialog box from the Menu Bar: Image>Image Size...
B. In the Document Size section of the dialog box, choose the units that you are most comfortable with (pixels, inches, cm, points, etc.),
C. Check the Constrain Proportions box,
D. Uncheck the Resample Image box,
E. Decrease the resolution to the target resolution. (Photoshop will do the calculation that will increase the physical dimensions proportionally. The file size will remain the same.),
F. Put the checkmark back in the Resample Image box and enter the target physical dimension into one of the Width/Height boxes (the number entered must be smaller than the numbers that currently exist in these fields),
G. Click OK.

Increasing the resolution on large-dimensioned, low-resolution images (which will reduce the physical dimension):

A. In Photoshop, open the Image Size dialog box from the Menu Bar: Image>Image Size...
B. In the Document Size section of the dialog box, choose the units that you are most comfortable with (pixels, inches, cm, points, etc.),
C. Check the Constrain Proportions box,
D. Uncheck the Resample Image box,
E. Increase the resolution to the target resolution. (Photoshop will do the calculation that will decrease the physical dimensions proportionally. The file size will remain the same),
F. Put the checkmark back in the Resample Image box and enter the target physical dimension into either one of the Width/Height boxes (the number entered must be smaller than the numbers that currently exist in these fields),
G. Click OK.

Increasing both resolution and physical dimensions:

This is often what you need to do with images lifted from websites. Ideally, you should try to reacquire the image to meet your needs, but if that is not possible try this strategy. Be mindful of copyright issues when using images from websites. The best thing is to do is to get permission from the copyright holder, failing that, you could try finding an image that is available with Creative Commons permissions through sites like Flickr.

You will find moderate success in increasing the resolution and/or physical dimensions by this method.

For images that are both small-dimensioned and low-resolution, and therefore lacking the dimensions to "Rob Peter" in the steps previously described, try increasing the resolution/physical dimension in 10% increments by resizing by resampling:

A. Open the Image Size dialog box from the Menu Bar: Image>Image Size... ,
B. In the Document Size section of the dialog box, choose the units that you are most comfortable with (pixels, inches, cm, points, etc.),
C. Make sure the 'Constrain Proportions' and the 'Resample Image' boxes that are at the bottom of the dialog box are checked,
D. In the Document Size section, increase the document's physical dimension or resolution no more that 10% larger than the original size,
E. Click 'OK'.
F. Repeat steps A-E until target resolution and physical dimension nearly reached.
G. For the last iteration, enter the exact dimensions and resolution you are targeting.

Resizing with the Crop Tool

Some images contain enough data to resize with the Crop Tool. It works best if reducing the resolution and/or the physical dimension of the image. To increase either the physical dimension or resolution of an image, there must be an excess of either resolution or physical dimension, because Photoshop will be appropriating the excesses to the other dimensions.

To increase both the resolution and physical dimension of the image, follow the instructions outlined in the previous step.

figure 12 *The entire image or a selected portion of an image can be resized by using the Option Bar with the Crop Tool.*

Select the Crop Tool to activate the Crop options in the Option Toolbar
Insert the desired physical dimensions and/or resolution in the Option Bar (these numbers will persist for every image you open so you can crop multiple images uniformly for creating composite images). It is unnecessary to fill in each field- leave any two fields in this Option Bar blank.

To return to manual cropping with no preset numbers, press the Clear Button in the Option Bar.

Raster Objects:
Getting Them Into PowerPoint And Other Office Documents

Once you are done editing the raster image for physical dimension, file type, resolution and color mode it's time to combine them with other raster images and/or vector images and annotate. Since Photoshop and GIMP are poor tools for this- they handle text and annotations poorly and graphs and charts even worse, the best option is to use PowerPoint.

For a more detailed recipe, including information on how to determine resolution and physical dimension targets for raster objects, refer to *Creating Figures* handout. The following describes the proper method for inserting raster images into a PowerPoint file.

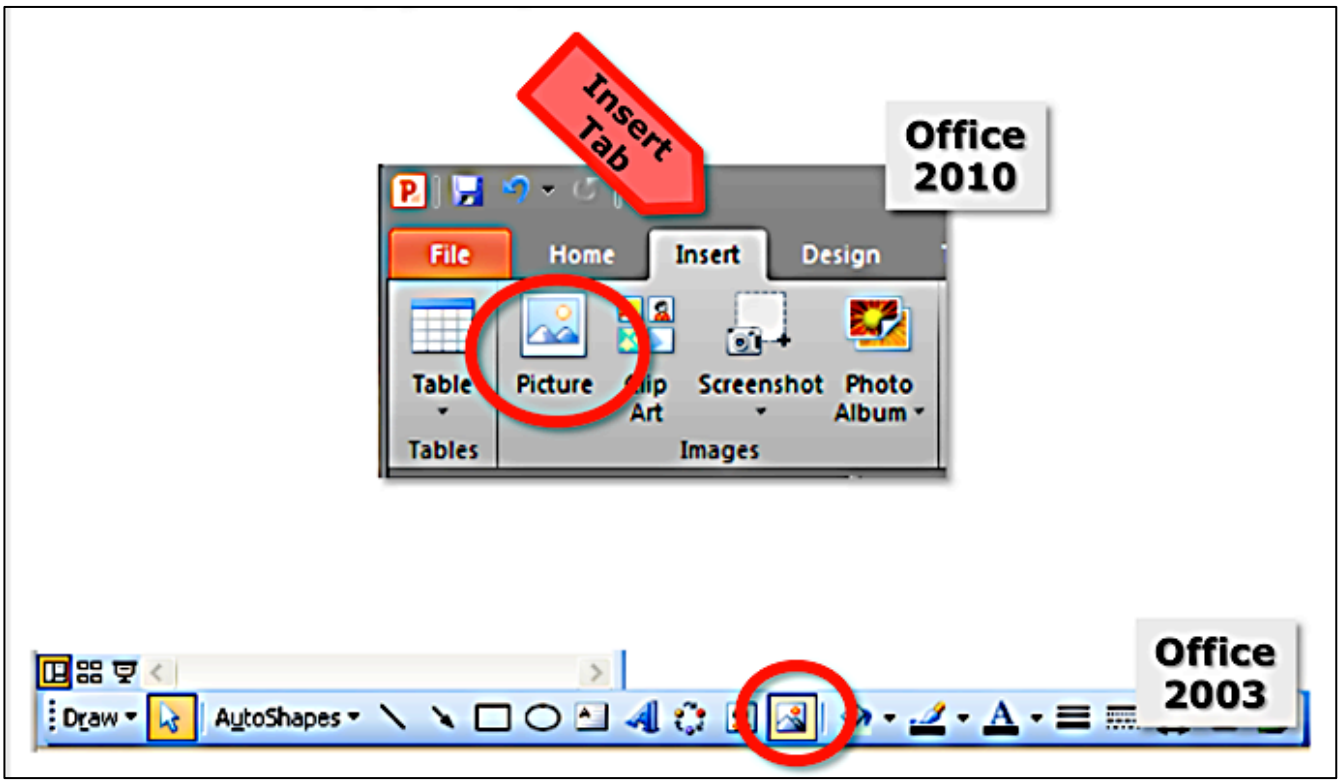


figure 13 *inserting rasters on* ***Windows Machines:*** *Insert (do not Copy & Paste) edited pixel-based images into PowerPoint. Adjust placement, add captions and annotate pixel-based images within PowerPoint*

Remember, do not resize images once inserted into PowerPoint- all resizing should be done before, using a pixel-based image editing application like Photoshop or GIMP.

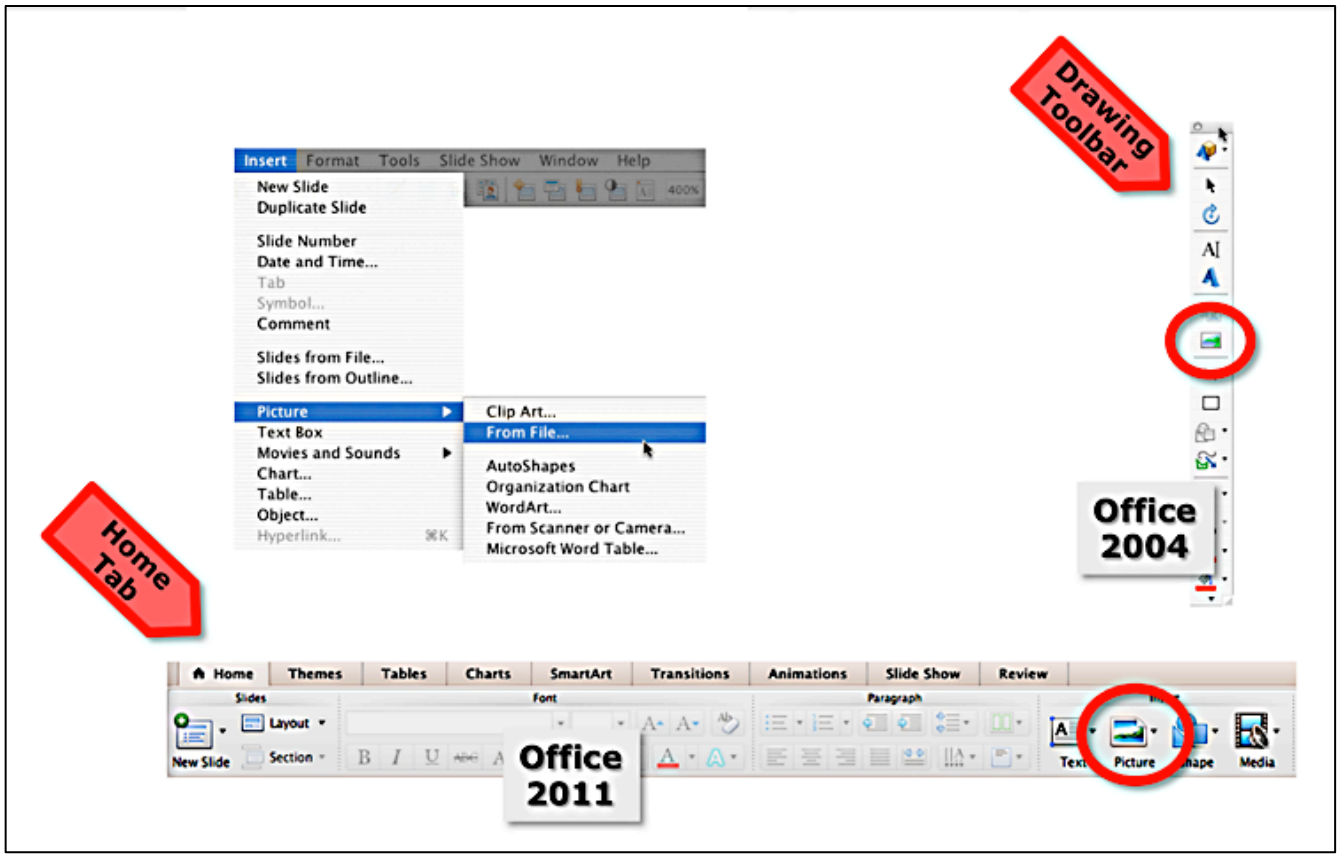


figure 14 *inserting rasters on a* ***Mac:*** *Insert (do not Copy & Paste) edited pixel-based images into PowerPoint. Adjust placement, add captions and annotate pixel-based images within PowerPoint*

Vector Objects:
Getting Them Into PowerPoint And Other Office Documents

There are certain benefits to using vectors within figures created in PowerPoint. Because vectors are mathematical algorithms and not made of pixels, it is easy to resize the object within PowerPoint. Simply select a resizing handle and resize- there is no degradation of image quality since there are no pixels to 'stretch'. To maintain the proportions of the vector object, hold the Shift Key while resizing it and use one of the object's corner handles. Also know that many vector objects can be 'Ungrouped' within PowerPoint, allowing only particular elements of the figure to be edited (resized, recolored, deleted, text edited, etc.), then 'Grouped' again as one vector object.

You may have created tables, graphs, cartoons or other vector objects in other applications (Word, Excel or other scientific applications that generate vector objects). These vector-based objects often will incorporate well into figures created with PowerPoint. This method is the preferred way to handle vectors because of their superior quality. Since they are vectors they are easily edited within PowerPoint, eliminating the need to use Photoshop for editing.

Important: Vector objects should NOT be edited within the pixel-based Photoshop application- it will rasterize the graphic and make it blurry. If, however, using the *Copy & Paste* or *Paste Special* methods yield unsatisfactory results, you may need to deliberately rasterize a vector and use Photoshop.

When to *Copy & Paste* vectors:

On the Mac, with Office 2008 or Office 2011

When to *Paste Special…* vectors

On the Mac, in Office 2004 or earlier
On the PC, in any version of Office (always!)

When to make a raster from your vectors:

When PowerPoint fails to keep vectors as drawing objects and rasterizes the object. This can happen with under certain circumstances with newer versions of Office, versions that were released during 2007 and later. This is a particular problem for Illustrator drawings and some scientific applications.

How to *Copy & Paste* vectors:

On the Mac, with Office 2008 or Office 2011

Go to the source vector object you would like to use and *Copy* it
Go to the document that you would like to use the vector object in and *Paste* it

How to *Paste Special…* vectors:

On the Mac, in Office 2004 or earlier
On the PC, in any version of Office (always!)

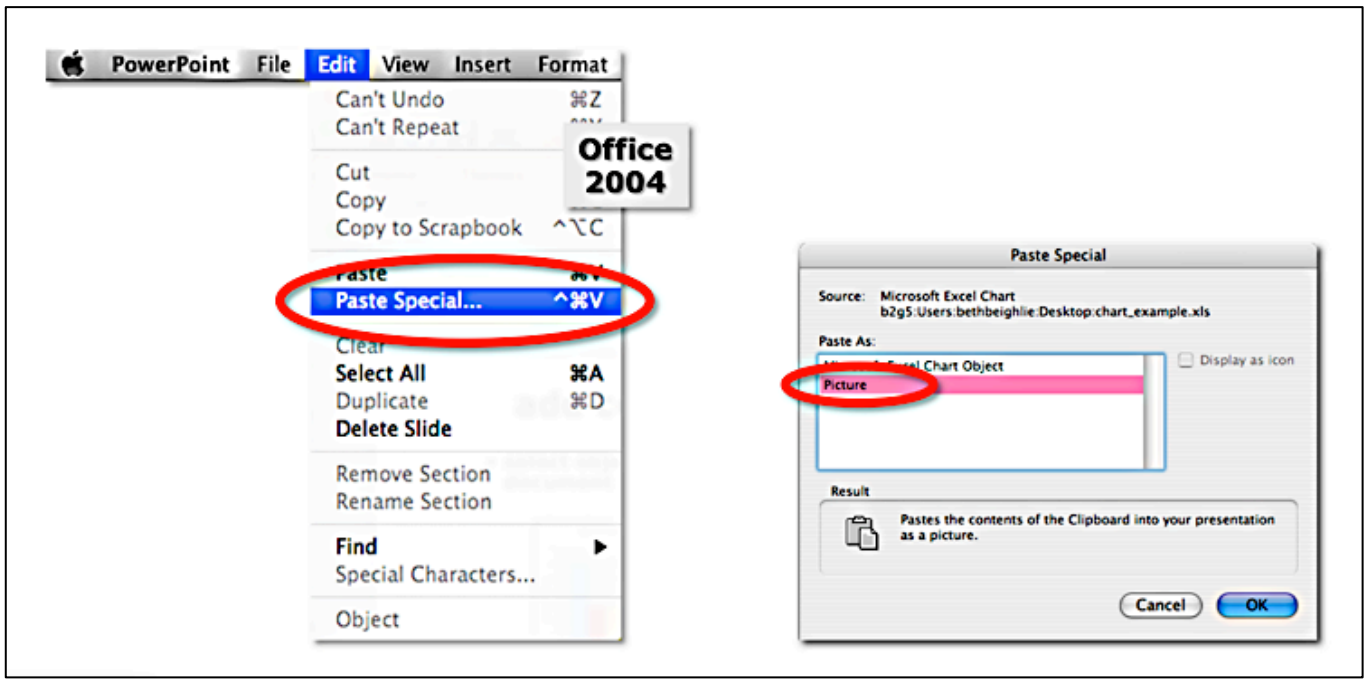


Figure 15 *Paste Special... on the* ***Mac*** *using Office 2004*

A. Go to your source document and select a pre-existing vector object (chart, table, graph or other vector object).
B. *Copy* it
C. Go to your target document and *Paste Special…*
D. In the *Paste Special…* dialog box

- if on a Mac, choose *Picture*
- if on a PC, choose *Picture (Enhanced Metafile) or Picture (Windows Metafile)*

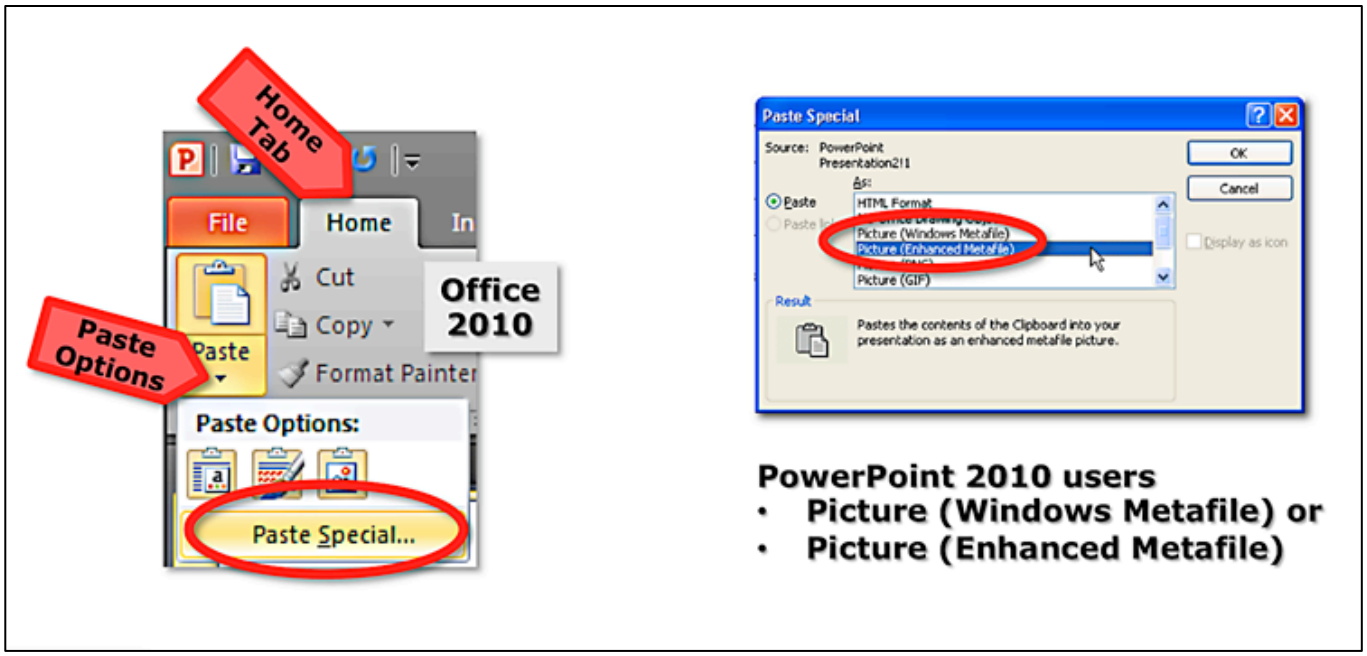


figure 16 *Paste Special... on a Window's Machine using Offce 2010*

Editing Vector Objects Within PowerPoint

You may wish to edit the vector object once placed into the poster. Regardless of how the vector was placed in the poster, grabbing a selection handle will allow you to resize.

After resizing vectors, it is important to proofread all the text elements carefully.

Text can be resized, font styles changed, objects and lines recolored and elements can be moved or deleted.
If the vector was inserted with the simple *Copy & Paste* method, you will be able to select and edit particular elements without *Ungrouping*.
If the vector was inserted by doing a *Paste Special*…, then the vector needs to first be selected and *Ungrouped*.

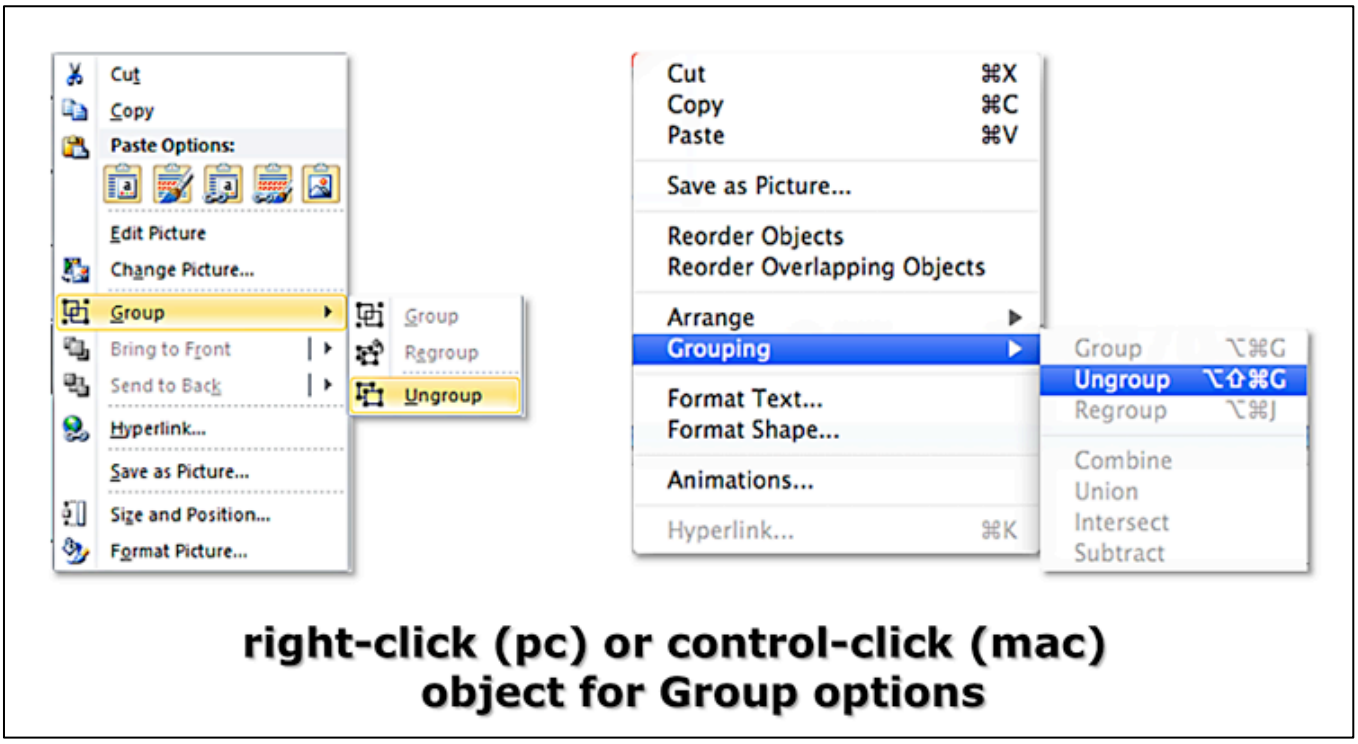


figure 17 *Ungroup and Group elements for additional editing features and control*

Once finished editing vector elements, regroup them.

For more information on creating different file formats from figures created with PowerPoint, see the *Output Options* handout at it.med.harvard.edu/ris

How to make a raster from your vectors:

Given the choice, don't. Just don't. But there may be a reason you need to.

The versions of PowerPoint that were released in 2007 or later have taken several steps backwards in terms of how they handle vector objects. In some cases when *Paste*-ing or *Paste Special*-ing vector objects, PowerPoint will automatically rasterize the drawing object. The quality is usually terrible, since you are unable to control the resolution or size.

It is often better to use the application that made the vector to create a new raster version of the illustration.

A. Usually this can be done using either the *File > Export* or *File > Save As…* options
B. Save the file as a .PNG, .TIF or .JPG file type
C. You will almost certainly need to change the physical dimension using Photoshop, so save the file at an exceedingly high resolution: 600 dpi or better
D. With that resulting raster file, determine the target resolution and physical dimension and use Photoshop or some other pixel-based image editing application to correct the resolution and physical dimension.

See ***Determining target resolution, dimension, color mode and file type for rasters*** section in this document for information on that task.

See ***Resizing raster images*** section for information on how to make changes to resolution and physical dimension.