Office of Digital Collections and Research
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Digital Imaging Primer

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Digital Imaging Primer

Digital imaging tools may be among the most commonly used pieces of hardware and software, while digital images themselves remain a mystery to many. Digital images combine properties related to their technical nature as digital files as well as those that come with proper image capture such as lighting and focus. To fully understand either of these sets of properties requires specialized expertise gained through education, experience, and skill. However, some of the more basic properties can be easily grasped and applied to the creation and management of digital images and archives.

This document will explore the basic properties of digital image files and how they affect the overall quality of digital images. Where relevant, current policies regarding image specifications set forth by Digital Collections and Research (DCR) are included. These policies are intended to set a standard for the minimum acceptable quality of images kept by the University of Maryland Libraries as digital preservation masters.

A number of decisions regarding the creation of digital images are left to the discretion of project managers. This document is intended to help inform decisions made when creating or managing digital images for projects managed by DCR. Guidance here should be used in tandem with that outlined in the *Best Practices for Digital Collections at the UM Libraries* to determine the best digitization procedures for project goals and workflow.

This documentation covers the use of the Epson Expression 1640 scanner and the Epson professional scan interface. Future editions of this documentation will cover the Microtek i900 scan interface and Nikon Supercoolscan 500ED.

Part One: Digital Images from the Ground Up

1.1 What Is a Digital Image?

Digital images have two basic components: pixels, and print size. These components can be changed, either individually or in tandem, to achieve different affects.

The basic digital component of an image is the pixel. This is the smallest piece of digital information in the image. Pixels are used to created the dots of color that make up the image. This concept should be immediately familiar from analog-world examples like the Pointillist paintings of Seurrat or the dots of color used to print old comic books.

When viewed on a computer monitor, pixels always measure 1/72 of an inch, in both height and width (in other words, there are 72 pixels in an inch). When an image is printed or used by another type of software, the pixels can be stretched out to fit a specific print size, the third component of digital images. Expressed in inches, centimeters, picas or some other unit of physical measurement, the print size may be smaller or larger than its pixel height and width as viewed on a monitor. When this happens, the output device (either a screen to view the image or a printer) stretches or compresses the dots of color to fit in the print size.

The number of pixels in an inch of the print size determines the overall quality of the image, referred to as "resolution." These two factors normally have an inverse relationship to one another. Therefore, if the print size increases and the number of pixels stays the same, the pixels per inch (ppi) decreases meaning that resolution is lowered and vice versa. When this type of change is made, the number of pixels and therefore the file size, is unchanged.

Dots are often used interchangeably with pixels in the expression of the resolution of a digital image (as dots per inch or "dpi") although this technically refers to the resolution of a printed inch of the image.

Scanners and bitmap image editors (programs that allow you to edit images like Adobe Photoshop) allow manipulation of these properties independently of one another — resolution can decrease or increase with the print size for example. This process is generally know as "resampling," a process which deletes or creates pixels from an image to achieve a desired effect. In some cases resampling is desirable, particularly in the case of decreasing resolution and file size. On the other hand, increasing is almost never desirable. When an increase in resolution occurs, the computer has to interpolate the new pixels based on the surrounding pixels. Since the computer is really only guessing what the pixel's properties should be, the resulting image appears fuzzy or slightly out of focus. In addition, artifacts or noise may be introduced or exaggerated.

For example, resampling a 300 ppi JPEG down to 72 ppi while keeping the file size the same would result in an image that will look just as sharp on the monitor screen as it would in print (since the monitor displays 72 pixels per inch), but will have a much smaller file size for faster loading. On the other hand, if an image exists at 72 ppi the software would have to use interpolation to create an image at a higher resolution resulting in poor image quality.

When an image is not resampled when it is resized, the variables of resolution and print size have an inverse relationship to each other while pixel dimensions (and the file size) remain the same. So if a slide that measures only 1 x 1.5 inches is needed at a print size of 4 x 6, capturing the original slide at a very high resolution and then choosing not to resample when the image is resized will result in an image of the same file size with a lower ppi (and therefore a lower image quality) but a larger print size.

To avoid this, digital images that need to be enlarged greatly for a specific purpose should be captured at a very high resolution to minimize the later decrease in resolution. When resizing is done, the print size and resolution should change inversely to each other, keeping the file size the same. In other words, file size is the key factor to consider when enlarging an image. When images are scanned without a known need for resizing, they should be scanned to meet the minimum requirements for resolution according to "Appendix V: Minimal Requirements for Creating Digital Images" in *The Best Practice Guidelines for Digital Projects at the UM Libraries*. To learn how to resize images, and to calculate scanning resolution for images that will be resized, refer to sections 2.1 and 2.4 in "Part Two: 'How to" Techniques for Digital Images Using Photoshop" in this document.

1.2 WHAT ARE PIXELS MADE OF?

Although the preceding sections discussed the nature of the pixel as carrier of color and size information, a deeper understanding of the makeup of the pixel itself is needed to fully understand digital images. Understanding the way content in the pixel is organized helps image creators determine and manage color palettes and file sizes.

In the simplest terms, the pixel is a package of bits — a series of ones and zeros that are translated by the computer into meaningful information. The "bit-depth" of a pixel refers to the number of bits it contains and therefore the number of possible combinations of ones and zeroes. This bit-depth in turn determines how many different colors the pixel could have. All the pixels in an image will have the same bit-depth and the same palette of possible colors.

The simplest images use only one bit (1 or 0) to express one of two colors (usually black and white) in each pixel. 2-bit color offers two bits per pixel, leading to four possible combinations (00, 01, 11, 10) and therefore four tones for each pixel. This is known as quadtone color, but is rarely used in imaging. More common is 8-bit color (eight bits per pixel, leading to 256 possible combinations), which is used for grayscale and indexed color profiles.

In these bit-depth profiles, the pixel is storing only one channel of color, meaning that each new color has a completely new combination of bits. For instance, purple and violet would be two completely different combinations, despite the fact that they are similar in hue. Beyond eight bits, most bit-depth profiles start to divide bits into separate channels that each represent multiple shades of a single hue. These channels are then combined by the computer, much the way paint colors are mixed. For example, a 24-bit profile may use three channels: red, green, and blue. Each channel uses 8 bits to express 1 of 256 possible shades of that color. The three channels are then combined to make a single color. This combination results in millions of different shades expressed through a total of 24 bits per pixel (8 bits per channel * 3 channels = 24 bits).

The R, G, B profile described in the previous example is the most used bit-depth profile for digital images. If a scanning or image editing interface says simply "color", it can usually be assumed to refer to an 8-bit, R, G, B profile. Newer scanners and bitmap image editors also sometimes offer the option for 16-bits of color per channel leading to a total of 48 bits per pixel. The main benefit of this extra information is smoothness when retouching images. Whether or not this profile has any archival advantage is debatable. If the image that is scanned will not have to be retouched, the smaller bit-depth will save storage space. However, the fact that the final use of these images is not known may be reason enough to decide to go with the higher bit-depth.

Unfortunately, interfaces for different programs express these bit-depths differently. Some focus on the number of bits per channel (8 and 16) while others express the total bits per pixel (24 and 48). For example, Adobe Photoshop uses 8 and 16 instead of 24 and 48, which is used by the Epson scan interface. When working between these programs it is important to remember whether bit depths are being expressed by channel or by pixel.

For best results, materials should be scanned using the color profile and bit-depth they will need for archival purposes, as there may be differences in how colors are expressed if color modes are changed after scanning. Most flatbed scanners will offer the basic color profiles as follows.

Black and White (1 bit): Black and White color profiles assign every pixel in the image either a purely black or purely white value. This mode is not suitable for use with any kind of photographic image, but may be used with line art or clearly printed text when a very low file size is desired.

Grayscale: Grayscale color profiles assign each pixel a shade of neutral gray completely devoid of any color using either 8 or 16 bits in a single channel. This profile can be used for black and white photographs or illustrations as well as text, but is not preferred for archival purposes, even in the case of black and white photography. Many images that appear grayscale may actually be a monochromatic image in another value, for example various shades of sepia or faded bluish-grays rather than a true black to white scale of grays. In addition, even images that are made of truly neutral grays may contain subtle shading that can not be captured with the limited number of shades that an 8- or 16- bit Grayscale color profile can capture. Therefore, use grayscale only when the image may not be kept for archival purposes.

Halftone: Halftone is actually a process of translating images into a series of dots, lines, or other shapes of one color, usually black on a white background. This type of image is commonly used in newsprint and magazines. This type of scanning will generally not be used in library projects.

Indexed color: Indexed color is a limited palette color profile. As such, it should be used only with simple graphics and thumbnails that may be expressed using a palette of 256 colors. This mode may limit the ability to save in different file formats (for example, GIF is possible, JPG is not) or use certain filters in a bitmap image editor. Its use in scanning will be rare, although it may be used later for creating derivatives.

RGB color: RGB stands for "**R**ed, **B**lue, **G**reen," the primary colors of light, and hence the primary colors a monitor can display. Every color seen on a screen is a combination of these three hues. RGB is usually captured in either 8- or 16-bit per channel (24- or 48-bit total) bit-depth. Since this color profile reflects the closest relationship between the digital file and what is seen on the screen, it is considered an archival standard. Some scanners may allow you to choose a specific RGB profile from among several. These profiles vary in the way they translate color settings to different monitor settings. If the choice is presented, DCR's recommendation is the Adobe RGB (1998) color space.

CMYK color: CMYK is the industry standard color profile for professional printing. The acronym stands for "**C**yan, **M**agenta, **Y**ellow, and blac**K**," which are the primary colors of ink used in offset printing. When scanning an image for professional printing it is best to scan it in CMYK, if at all possible. If CMYK is not available, it is necessary to scan the image in RGB mode and convert to CMYK in Photoshop. Once this conversion is done some time may have to be spent in adjusting the color values to more accurately reflect the image.

In addition, **spot colors**, such as the Pantone™ color system, may be supported by various applications. Spot colors are special colors that do not fit into the other color modes. They should only be used when an outside vendor requests them for printing

1.3 How Are Digital Images Saved?

Once digital images are created they may be saved in a number of file formats, each of which has distinct advantages and disadvantages with regards to compression, metadata, and interoperability. The most important factor of these three is compression, which is described in section 1.3.1.

1.3.1 Compression

Compression refers to a mathematical process that reduces file size in images by discarding inessential data. Lossless compression uses an algorithm that can completely restore the data of the original image when decompressed, producing an image that is in no discernable way inferior to the original and reducing file size up to 50%. Different types of lossless compression are referred to by the name of the algorithm used to perform the compression.

Lossy compression, on the other hand, can't always retrieve compressed data that is exactly the same as the original data. This is a much more efficient way of reducing size resulting in more than 50% compression. However, if the compression rate is too high a degradation of the image quality may be seen. One type of lossy compression used in digital images works by taking a sample of pixels from an image and then predicting what the color of the unsampled pixels will be. The predicted values of the unsampled pixels can often be imprecise leading to a loss of detail in images or even the introduction of noise and artifacts. With higher rates of compression smaller numbers of pixels are actually sampled. The information about the color the predicted pixels originally had is unrecoverable with this type of compression.

1.3.2 Common File Types

Some of the most common image file types are:

Tagged Image File Format (TIFF)

TIFF images are the defacto standard for archival preservation at the UM Libraries and beyond. These images are considered desirable for several reasons. The first is that they can be either compressed or uncompressed, and when compressed can use either a lossy or lossless algorithm. In addition, TIFF files can store a limited amount of metadata related to technical properties of the image. TIFF files are largely accepted in many software programs, although at the moment no web browser supports viewing this file type.

It is UM Libraries practice to save a scanned or digital still camera capture as an uncompressed TIFF file with an Intel (Windows) byte order as the preservation master. After this file is saved access copies or edited copies can be made and saved in TIFF or other file formats.

Joint Photographic Experts Group (JPEG)

JPEG images are commonly used for access copies, especially for web delivered images. They have a user-determined, variable rate of compression using a lossy algorithm, resulting in much smaller files than their TIFF counterparts. In addition, JPEG files are web deliverable and commonly used in many image-related software programs. They have no capacity for metadata.

JPEG2000

JPEG2000 is a relatively new file format created by the Joint Photographic Experts Groups. One outstanding feature of JPEG2000 is its ability to compress files up to 200% with no loss in quality. However, implementation of JPEG2000 is still not complete limiting its cross-compatibility. For this reason JPEG2000 has not been generally accepted as a preservation standard or access copy standard yet at the UM Libraries.

Graphics Interchange Format (GIF)

GIFs are an 8-bit-per-pixel file format widely used in web graphics. Although this file format employs a lossless compression algorithm, the limited color palette means that these files are not suitable for large images, although they may be used for thumbnails. GIF images are compatible with many software programs and browsers and some version can carry application-specific metadata.

Adobe Photoshop File (PSD)

Files created by the bitmap image editor Adobe Photoshop are a proprietary file format that is compatible only with other Adobe products. Although this file type should not be used as a preservation or access copy, these files should be kept if any enhancing or editing is done with Photoshop to ensure that further changes can be made or reversed.

Other file types

In addition to these standards, other file types may be encountered at the UM Libraries. Raw image files, which are the minimally processed data files from a digital still camera or scanner are sometimes kept for archival purposes. Raw files cannot be viewed, printed, or edited before they are first converted to a known format. When raw files are saved from a digital camera or scanner they must then be manually converted into an RGB color profile. Raw files may be created and saved for a digital project but will not be considered preservation or access copies. Raw files have different file extensions based on the device from which they were created.

Bitmap files (BMP) or Portable Network Graphics (PNG) files may also be occasionally encountered. BMP files are uncompressed, but use only 2-bits-per-pixel, making them suitable only for simple web graphics. The PNG format was created as an improvement to the GIF format. It therefore uses lossless compression but can have more than one color channel increasing the palette of colors over GIF. Many bitmap image editors and browsers support both of these file types but due to their limitations they are not recommended for access copies.

1.4 How Are Digital Images Created?

1.4.1 Scanners — Taking a Picture of a Picture

Scanners are designed to create digital images from existing documents in one of two ways. Either an image sensor moves, or 'scans' over a stationary object as in flatbed, slide, or planetary scanners, or an object is moved past the sensor as in drum or rotary scanners. The most typical kinds of scanners used in UM Libraries are flatbed and slide scanners. While scanners and digital still cameras do create the same output (digital images) digital cameras require a different set of skills to operate. Digital cameras will be discussed in section 1.4.2 of this document.

The scanner itself is operated through an installed software interface. An example of such an interface is shown in Figure 1.1. The basic tools offered in an interface allow the user to control the bit-depth/color profile, print size, and resolution. Advanced or professional scanning interfaces also offer tools to perform the following adjustments.

1.4.1.1 Exposure and clipping

Just as the creation of an image with a camera, creation of a digital image with a scanner depends on balancing the proper amount of light and dark in the image. Many scanning interfaces and bitmap image editors use histograms to represent the light and dark tones of the image by showing how many pixels in the image exist at each of the 256 colors that are available in each channel (from the darkest color "0" to the lightest color "255"). The histogram can be viewed for just one channel or for all three combined. If the image is properly balanced, all of the pixels in the image will occur within the black and white sliders that appear under the histogram, as can be seen in Figure 1.2 and 1.3.

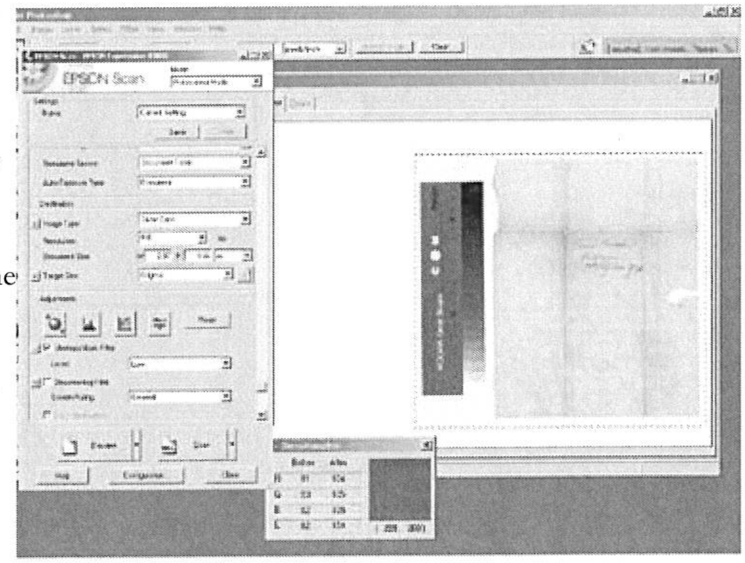


Figure 1.1: Epson Scan Interface

The values between the white and black sliders are the values the scanner actually captures when it scans. Any pixels that have a color value that occurs outside of the sliders of the histogram will not be captured in the final image. Those pixels that are being captured are then translated to the "Output" values, seen below the input sliders. This means that the darkest pixels captured (those directly above the black slider) are being translated to the low output value, and the lightest pixels (those at the white sliders) are being

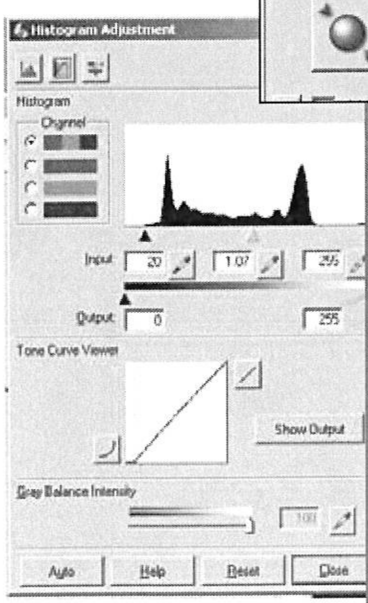


Figure 1.2: Histogram adjustment menu.

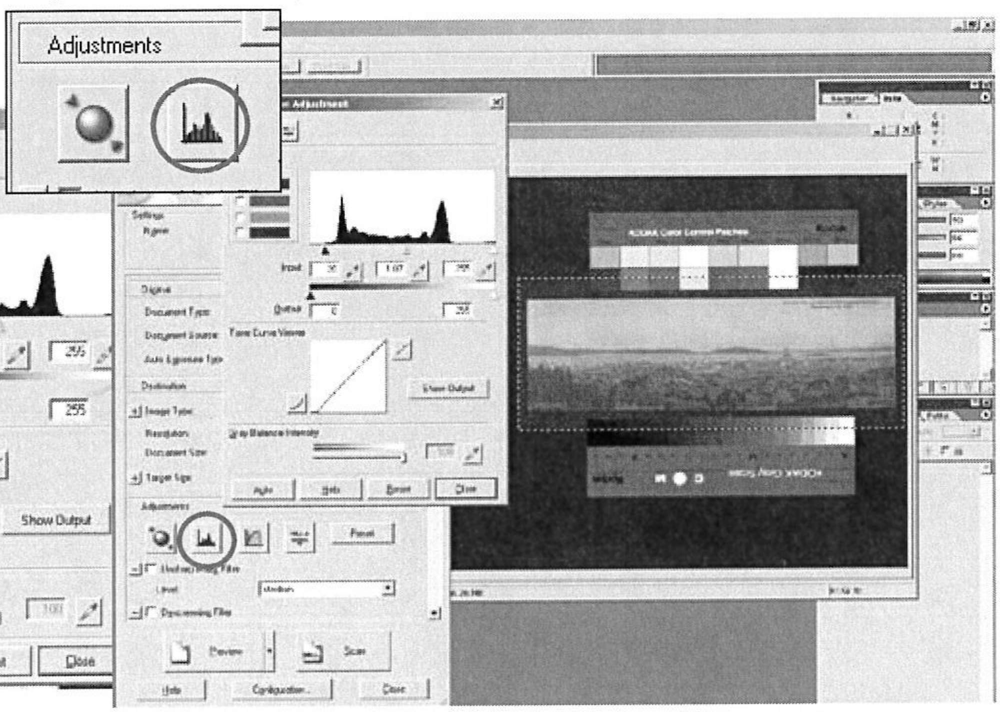


Figure 1.3: Histogram menu with scanning preview screen (inset: menu button on main interface window).

translated to the high output value. The scanner is redistributing the light information to correspond to those output values, stretching the histogram and effectively lightening the shadows and darkening the highlights to reveal more detail.

Since the scanning software effectively assigns a brightness level to the image, it is important to ensure that the brightness of the final image corresponds with the brightness of the original item through the use of targets. Using a tool called a densitometer, which is a part of the scan interface, the R, G, and B values for particular grayscale patches of the Kodak Q-13 target (the preferred target for the UM Libraries' Preservation department and DCR (Figure 1.4)) can be compared to the control R, G, and B values. Using the targets in this way provides an objective, quantifiable way of determining whether or not the scanner has achieved a proper exposure.

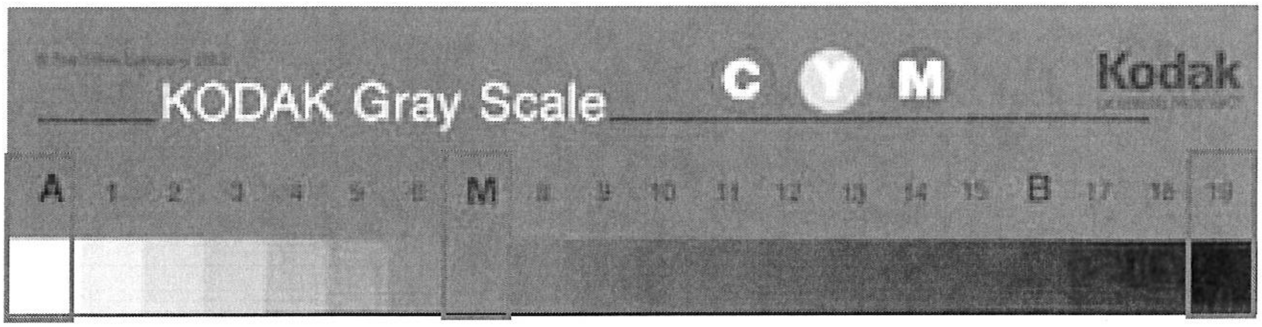


Figure 1.4: Kodak Q-13 Gray Scale Target showing A, M, and 19 patches.

If the sliders are improperly placed and some of the information in the histogram is left out, the resulting image will be "clipped." When this happens, information that is represented outside of the sliders will be translated to "0" and "255" and any subtle details that might previously have been seen here would be lost.

The goal with histogram adjustment is to have the pixels level off at either end and to see a range of peaks and valleys in between. But it is important to remember that the image itself will also affect the shape of the histogram. An extremely light image will have a very high peak on the right where lighter levels are recorded and almost no levels in the left. An extremely dark image has the opposite, peaks on the left and little or no information on the right. A low contrast image will resemble a plateau.

Most scanners have preset values or automatic exposure tools to clip out the lightest highlights and darkest shadows. This increases the visual sharpness or contrast of the image, but is a misrepresentation. Histograms should always be adjusted so that the levels in the 1, M, and 19 areas of the Kodak Q-13 target meet the accepted standards as found in *Best Practice Guidelines for Digital Collections at the UM Libraries*:

Q-13 Patch	A	M	19	B (alternative)
RGB levels (accepted range)	242-242-242 (239-247)	104-104-104 (100-108)	12-12-12 (8-16)	24-24-24 (20-28)
% Black (accepted range)	5 (3-6)	59 (58-61)	95 (94-97)	91 (89-92)

Figure 1.5 shows an example of an image before and after adjusting the histogram. Note the the way the white background of the scanner top are overexposed and the way the whitest value of the gray scale target can be barely distinguished from the background.

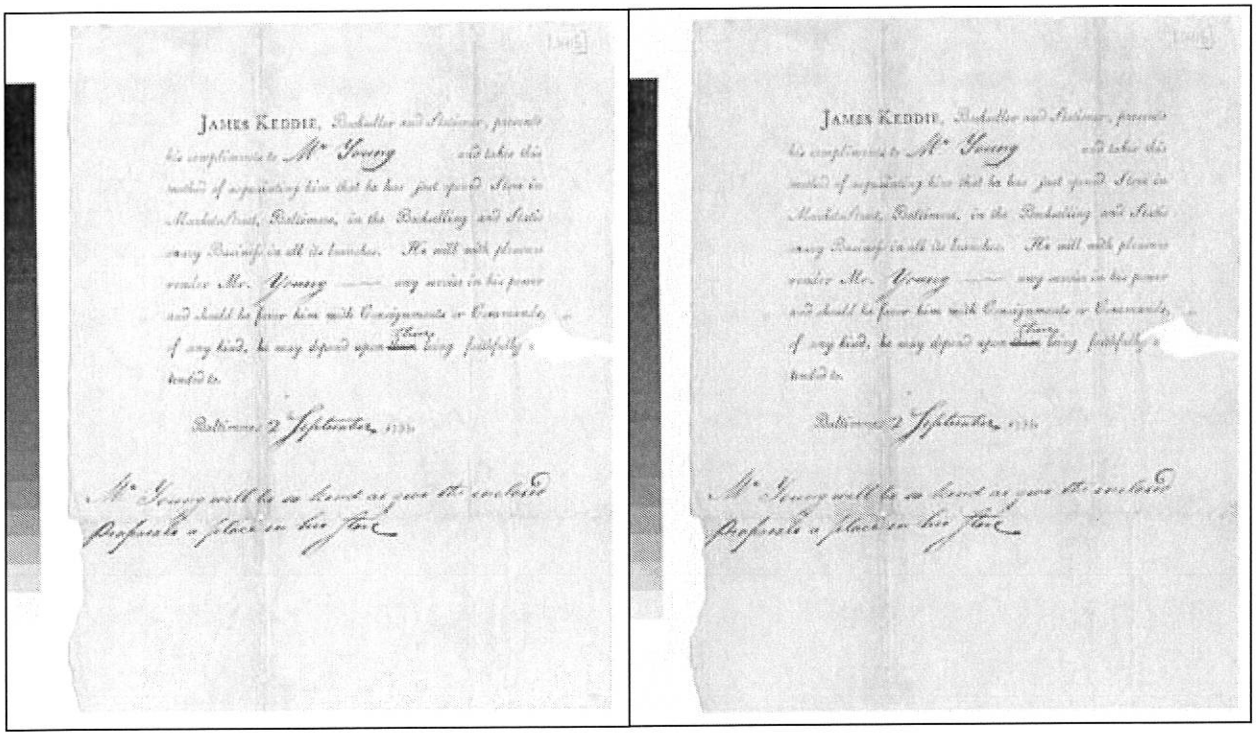


Figure 1.5: The same image before and after adjusting the histogram.

Directions for performing this sort of adjustment with the Epson scan interface are detailed in "Part Two: 'How to' Techniques for Digital Images Using Photoshop."

1.4.2 Digital Cameras — Taking a Picture from Life

Digital cameras are the second major mode of digitization for images. Although both of these tools achieve the same goal, a different set of adjustments are made with a camera than those used when operating a scanner. Since many resources exist to teach users how to manipulate camera settings, and since the tools and interfaces offered by digital cameras vary widely, the following section covers only a broad overview of the kinds of adjustments possible with digital cameras. This leaves the reader to explore other resources to learn how to manipulate the settings of a particular camera on their own.

1.4.2.1 Lighting

Just as in traditional photography, proper use of light sources is an integral part of the photography process. Spotlights, key lights, overhead lights, natural light, or flash bulbs may all be employed to ensure that objects are lighted in such a way that the camera can capture the details of the scene and obscuring shadows are not cast.

1.4.2.2 Lens Aperture

The lens aperture, or opening, determines the amount of light that enters a camera for capture and is measured in focal length. As focal length numbers, or f-stops, increase, the lens aperture decreases also decreasing the amount of light captured by the camera. The aperture that should be used is determined by the light available for capture and the exposure time, or shutter speed, of the camera. Most low-end consumer digital cameras use an automatic "point and shoot" method of setting the aperture based on predetermined settings. More professional grade cameras allow the photographer to manually control this setting for different effects.

1.4.2.3 Exposure Time

The length of exposure regulates the amount of time that the camera will capture information with its image sensor. This is analogous to the shutter speed of an analogue camera (and in fact may be referred to still as "shutter speed" by the maker of the digital camera) which determined how long the shutter is open to allow the film to be exposed to the light source. Manipulating the exposure time and lens aperture together enables the camera to continue to capture adequate amounts of light in varying conditions. For instance, in very low light situations, a long exposure time and large aperture will allow more light to enter the camera resulting in better image capture. On the other hand, when an object is moving very quickly a fast shutter speed and small aperture will do a better job of capturing a "freeze frame" of the object with no blur.

1.4.2.4 Digital Camera Resolution

A big difference between the use of digital still cameras and scanners is in the calculation of resolution. Digital still cameras create images with a specific number of pixels along the vertical and horizontal axes. These two numbers are multiplied to find the number of pixels in the combined area, expressed in megapixels. Cameras usually advertise their resolution as this megapixel value. The resolution of an image taken with the camera is then determined by dividing the number of pixels captured (either along one axis or the square root of the combined area) by the print size chosen (again along one axis or the square root of the combined area). For example, an image with 2049 pixels along its width and a total of 3.1 megapixels would have a resolution of 300 ppi if printed at 6.83 inches along its width (2048 / 6.83 = 300).

Just like scanners, digital still cameras can also interpolate resolution, usually advertising it as the "Digital Resolution" or "Digital Zoom". The camera's true resolution, without interpolation, is expressed as the "Optical Resolution" or the "Optical Zoom".

As with scanner capture, institutional guidelines regarding the use of targets and area of capture should be followed for digital still photography. These guidelines for UM Libraries are outlined in *Best Practice Guidelines for Digital Collections at the UM Libraries.*

1.4.3 Bitmap Image Editors — Taking Pictures Above and Beyond

After digital images are created further refinements can be made using a bitmap image editor such as Adobe Photoshop. In all cases the data that is saved from the scanner or camera should be saved in the TIFF file format before any further changes are made. This original version will be the archival master copy and will be a candidate for the digital preservation system.

After the digital master is saved, access copies and derivative files may be generated. These access files could be mirror images of the archival master, or they might be derivative compressed files with any number of adjustments. None of these adjustments should be made to archival masters, even if they increase the perceived quality of the image. Although this seems counterintuitive, when any manipulation to the original image is done pixel information is changed, lost, or resampled altering the image's status as an archival master. Some of the common adjustments for access files are described in the following sections. More detailed directions for doing these adjustments with Adobe Photoshop are found in "Part Two: 'How to' Techniques for Digital Images Using Photoshop."

1.4.3.1 Resizing

Resizing creates a copy of the file at a different print size or resolution than the original capture. The specific dimensions and resolutions of these copies should be determined by project goals.

Image size is normally changed by manipulating the print size, pixel dimensions, and/or resolution. In addition, bitmap image editors allow users to decide whether resized images are resampled or not. As was discussed in section 1.1, when an image is resampled it will actually be regenerated at new specifications meaning that pixels may be added or taken away to meet new variables, changing the file size. This may be necessary when a smaller resolution is desired, but should never be used to increase resolution. When an image is not resampled the print size and resolution have an inverse relationship to each other but the pixel dimensions and file size remain the same. More information on how to resize images is contained in section 2.1 and 2.2 of "Part Two: 'How To' Techniques for Digital Images Using Photoshop."

1.4.3.2 Sharpening

Sharpening increases the contrast between pixels based on their RGB values. The filter looks for adjacent pixels that have different RGB values and slightly tweaks them to increase the contrast.

Although not all images will require sharpening, any scanner will soften an image somewhat. If the image is very distinct and high-contrast this softening effect may not be as readily apparent. Photographic images, especially slightly faded, older images may be the most notably softened. Sharpening an image will give it more distinct edges and a crisper appearance. Sharpening WILL NOT focus an unfocused image. Sharpening is only done to more accurately capture the image in hand NOT to restore the original image.

When the decision is made to sharpen an image the adjustment should always be done after saving a preservation master using a bitmap image editor's advanced tools. It is not acceptable practice to use the sharpening setting of the scanning interface and save an image as a preservation master.

Bitmap image editors allow the user to control how the sharpening is done through a tool called "Unsharp Mask". This tool usually involves adjusting the following variables:

- **Amount**: controls the amount of contrast that will be introduced into the affected pixels. This is how to control the intensity and detail in the image.

- **Radius**: increases or decreases the number of pixels surrounding the affected pixels that are also going to be affected. This can be thought of as a halo effect with the radius tool controlling the size of the halo. This tool helps to smooth the areas around the edges of the affected pixels.

- **Threshold**: affects the number of levels of difference that must exist between adjacent pixels for them to be affected. A higher threshold means that the number of levels of difference must be higher before the filter will affect them. So a Threshold setting of 5 will not affect two adjacent pixels with a brightness level of 110 and 114, but will affect those with levels of 110 and 115. This setting is used to fine tune sharpening. This adjustment reduces the noise in areas that shouldn't be noisy even though they may have some random pixel variations.

Information on how to use the Unsharp Mask in Adobe Photoshop is detailed in section 2.5 in "Part Two: 'How To' Techniques for Digital Images Using Photoshop."

1.4.3.3 Removing Moiré Patterns from Digital Surrogates

Moiré patterns, the noticeable interference patterns created by screen-printed originals, cause particular problems for digital image repositories. Moiré patterns that are noticeable when an image is viewed at one size, disappear when the image is resized, making them particularly difficult to manage when, as in UM's digital repository, multiple sizes of an image are needed.

This phenonmenon occurs because of the discrepancy between the dot pattern of the analog original and the pixel grid of the digital surrogate. When these two grids do not line up properly, the interference between the two can create repeating patterns. This interference can be increased or decreased when either pattern changes. Obviously, changing the pixels (by changing the size) can be an easy way to mitigate the problem, however, often images are needed at particular sizes to meet design requirements. A better method is to change the dot pattern by slightly blurring and then re-sharpening the surrogate of the image at the particular size you desire.

Since this edit involves a fundamental changing of the image pixels, which will affect the detail and information in the image this type of adjustment should only be done to a surrogate or access copy. It is also very important that this adjustment is done postscan and not through a a "descreening" filter in the scanning software. These filters edit the scanned image before it is saved, compromising its status as a digital master. Typically, this adjustment is not needed before an image is uploaded into the digital repository. It will occur behind the scenes as derivatives are made from the digital master. This adjustment might be done, however, in cases of exhibition, web, or print use or patron request.

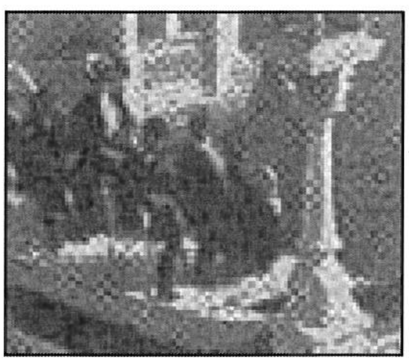


Figure 1.6: Image showing a moiré interference pattern.

Information on how to remove moiré patterns is detailed in section 2.5 in "Part Two: 'How To' Techniques for Digital Images Using Photoshop."

Part Two: "How To" Techniques for Digital Images Using Photoshop

2.1 Prescan: Adjusting Resolution to Enlarge Images

In some cases an enlarged image may be desired from the outset of a scanning project. Since information should not be added through interpolation to a file once it is scanned, it is important to calculate for this future enlargement before beginning. The following steps are used to determine an accurate scanning resolution to achieve an archival quality image at a different size.

1. Determine the final use or suite of final uses. Identify the final image size, color mode, bit-depth, and resolution for the final product.

2. Use the new file window in Photoshop (File -> New ->) to determine file size needed for scan.

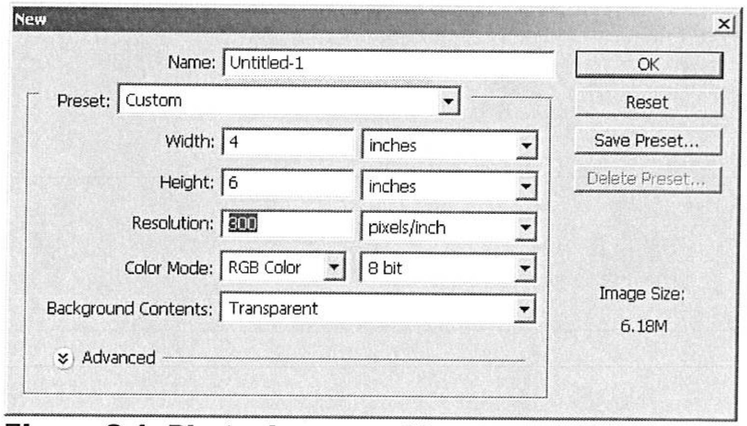


Figure 2.1: Photoshop new file window

3. The new file window in Photoshop (Figure 2.1) contains menu fields in the center of the window for width, height, resolution, and color mode including bit-depth. In addition, in the lower right-hand corner Photoshop has calculated the size of the image that will be created (directly underneath the words "Image Size:"). Making adjustments to the size, resolution, color mode, or bit-depth, will change this number. After changing these menu values to accurately reflect the end product desired, record the image size displayed and close the window. **Note that if Photoshop 6.0 or an earlier version is used, the file size will appear above the fields, next to the words "New Image".**

4. Next open the scanning software. This can be done by directly accessing the program, or, if the plugin is installed, choosing the scanner from the list displayed in the File -> Import -> menu in Photoshop. This should cause the scanning software to automatically open.

5. For flatbed scanners: Before making any changes to the scan settings, do a preview scan of the image. In the lower right of the scanning window the project file size of this image at the default setting for resolution, color mode, and bit depth is shown (see Figure 2.2).

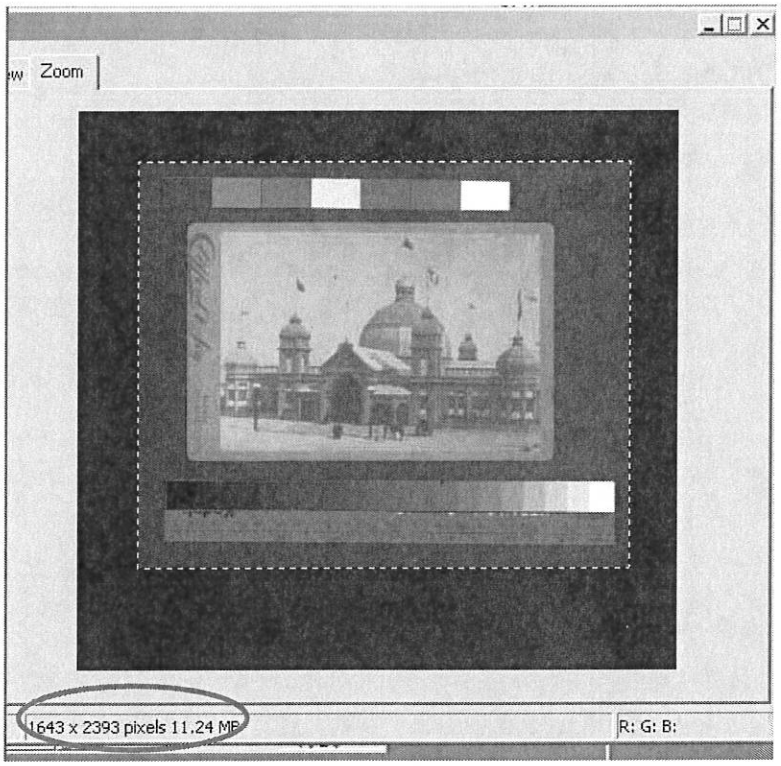


Figure 2.2: Preview window showing predicted file size.

Changes made to these settings also change the file size. Select the color mode/bit-depth combination that was used in the previous step and adjust the resolution until the file size in the scanning preview window is the same (or very close to) the size that was projected with Photoshop. This is the resolution to scan with for the desired result. Once the scan is completed follow the steps in section 1.2 for saving surrogates at different sizes without changing the file size.

NOTE: Never increase the resolution above the actual resolution capability of the scanner. Most scanners will interpolate scans at a higher resolution but the resulting image quality may be affected. The actual resolution capability of the scanner will be the lower of the two numbers in its model name, or will be noted in the scanner's manual or specifications as its "Optical Resolution".

2.2 Prescan: Histogram Adjustment

The histogram is the primary tool used to achieve the proper tonal balance of an image with a scanner. By adjusting the histogram sliders, (Figure 2.3) different swatches on a grayscale target can be readjusted to achieve a proper exposure. If the scanner interface does not offer this type of tool, the same adjustment can be performed to an unclipped image postscan (see section 2.3). This type of adjustment and evaluation of the target is integral to the creation of archival quality masters.

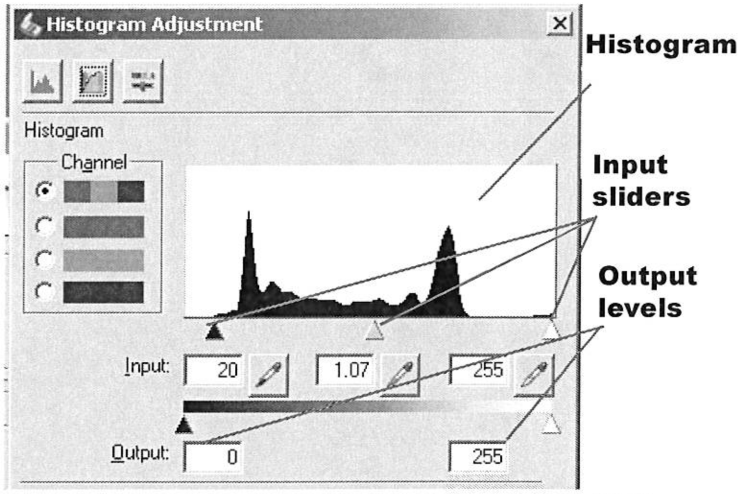


Figure 2.3: Histogram menu with sliders and output levels

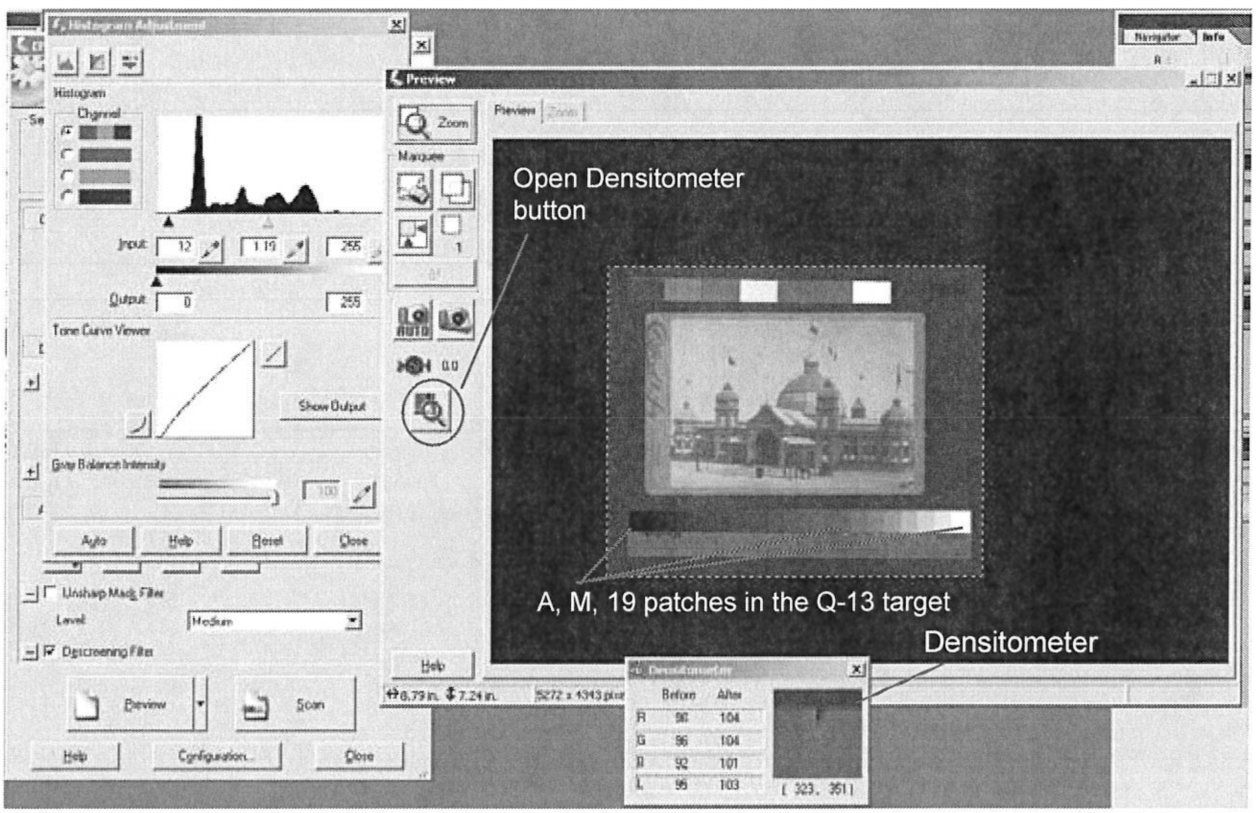


Figure 2.4: Preview window with histogram adjustment tool and Densitometer

1. Begin by opening the histogram tool after the all the items are placed properly and the prescan has completed (see Figure 2.4)

2. Ensure that the histogram is showing all three channels: R, G, and B and is not set to show one of the channels individually. Change the output values to 0 and 255.

3. Move the sliders just underneath each edge of the histogram shown on the graph.

4. Go back to the preview window and open the densitometer (Figure 2.4).

5. Place the cursor over the A, M, and 19 areas of the Kodak Q13 target (see section *1.4.1.1 Exposure and Clipping* and *Best Practice Guidelines at the UM Libraries* for more information on using these targets). Look at the "after" values in the densitometer (see Figure 2.5).

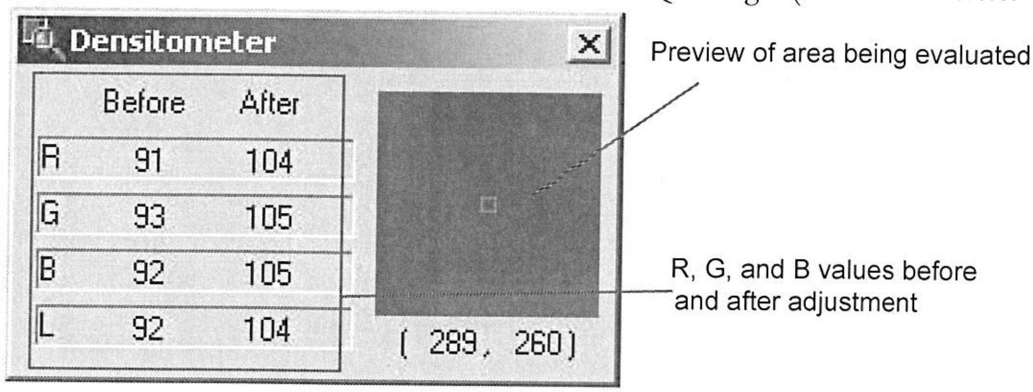


Figure 2.5: Densitometer window

The values for R, G, and B should be within the acceptable range for these patches according to the chart in figure 2.6 and should be within four levels of each other.

Q-13 Patch	A	M	19	B (alternative)
RGB levels (accepted range)	242-242-242 (239-247)	104-104-104 (100-108)	12-12-12 (8-16)	24-24-24 (20-28)
% Black (accepted range)	5 (3-6)	59 (58-61)	95 (94-97)	91 (89-92)

If the levels do not meet the standards, repeat steps 3-5 until the proper levels are achieved. Black and white sliders should always be adjusted before the gray slider is adjusted. Specifically, adjust each slider as follows:

a. If the levels in area 19 of the target (the blackest square) are too high adjust white slider to the right. If they are too low, adjust them to the left. In most images the white slider will be set to 255.

b. If the levels in area A of the target (the whitest square) are too high adjust the black slider to the left. If they are too low, adjust the slider to the right.

c. Adjust the gray slider to the right if the levels in area M of the target (the notched gray square) are too high, to the left if they are too low.

6. Once the grayscale patches of the Q-13 target appear to be within the proper ranges, close the histogram adjustment tool and scan the image. After the scan is finished and the image opens in Photoshop, use the Info palette (Window -> Info) to check the R, G, and B levels in the final image. If they appear to have drastically changed a problem may exist with the calibration settings of the scanner. Contact the project manager to notify them of the problem and determine how to proceed.

7. When the settings are finalized and the image is saved, be sure to close both the scan interface and the preview window to erase the previous settings before beginning a new scan.

2.3 Postscan: Evaluating Images for Clipping

Once images have been scanned, Photoshop can be used to evaluate the tonal balance of the image and whether or not (and where in the image) clipping has occurred using the histogram and levels tools.

1. With the image opened in Photoshop, choose Window -> Histogram.
2. Visually evaluate the histogram. Look for any clipping at either end. Don't worry if a caution symbol (⚠) appears on the histogram. It means that the preview image is generated from a cache. Simply click on the symbol to get the real histogram (Figure 2.6).

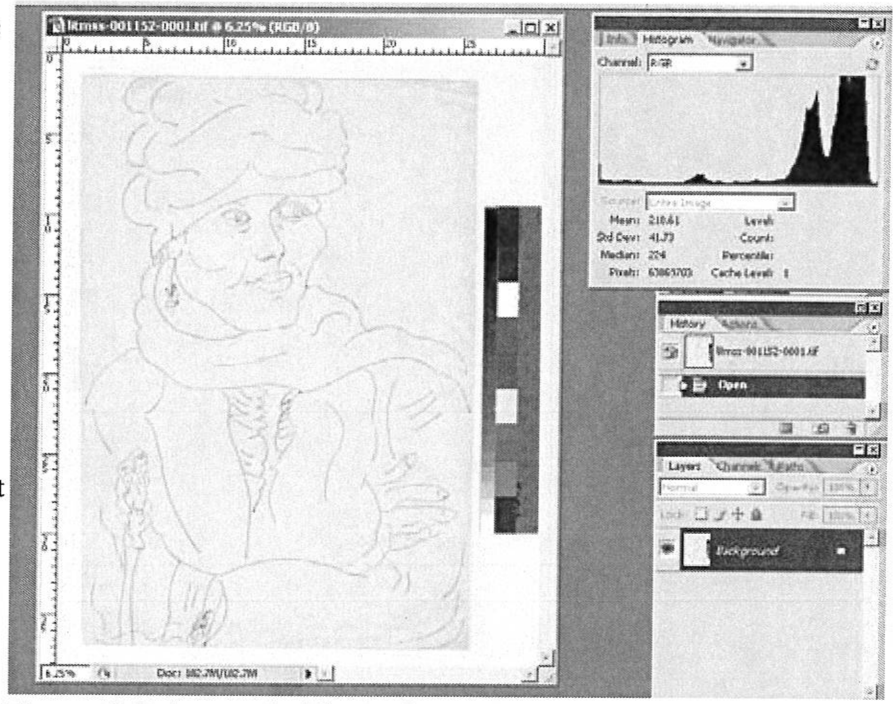
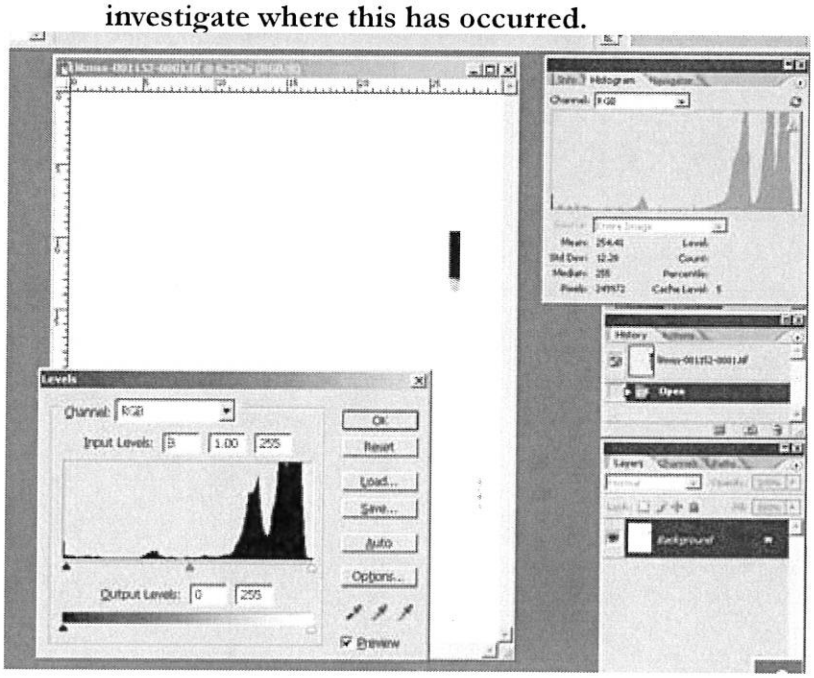


Figure 2.6: Image in Photoshop with histogram.

3. If the histogram shows some clipping, use the Levels palette to investigate where this has occurred.



   a. Open Image -> Adjustments -> Levels.
   b. Hold the alt key while clicking on the cursor underneath the clipped edge. The image should change to white with some blotches of bright colors (Figure 2.7).
   These bright colors indicate the pixels where clipping has occurred. The color

Figure 2.7: Using Levels to show clipping.

of the blotch indicates which channel has been clipped. The white areas are fine. Moving the slider will show what other pixels will be clipped if the histogram was adjusted thusly.

  c. If the clipping occurred in the target or the background, the image is still acceptable. If the clipping occurred in the image itself, the image will need to be rescanned using different settings or a different scanner

4. The Levels palette can also be used to readjust the target to hit specific aimpoints.

  a. Open -> Window -> Info.

  b. Choose the eyedropper tool and change the sample size (found in the top menu bar) to 3x3.

  c. Holding the shift button, click the eyedropper in the A, M, and 19 areas of the target. You should see the R, G, and B, values of the pixels at these points in the Info window (Figure 2.8).

  d. Next, open Image -> Adjustments -> Levels.

  e. You will see the histogram for all three channels combined. Adjust the sliders underneath the histogram until the R, G, and B values in the Info window match the target aimpoint ranges.

  f. You may need to adjust each channel separately to get all three levels within the range. If you are adjusting separate channels, check each for clipping by holding down the alt key and clicking on the slider. When viewing the combined histogram, the sliders may appear to be set to clip the histogram, but as long as the individual channels show no clipping, the resulting histogram should be balanced.

5. Click "OK".

6. Open Window -> Histogram again and view the results. Readjust as necessary.

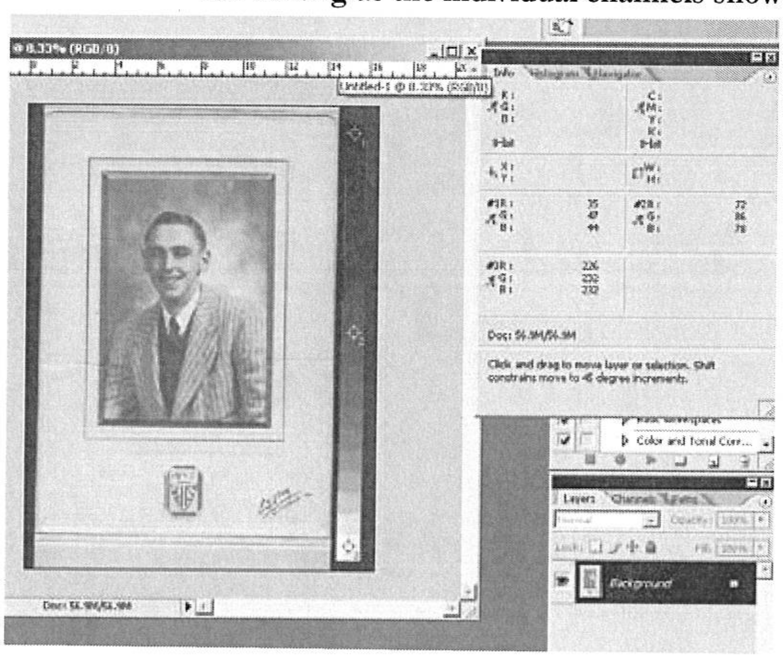


Figure 2.8: Using Info Window to see aimpoints.

2.4 Postscan: Resizing and Saving Derivatives

1. Choose File -> Save As from the top menu in Photoshop.

2. Name the file appropriately and then choose TIFF from the file format options as in Figure 2.9.

3. After the "SAVE" button is pressed, a second menu will open asking for compression and byte order options. Make sure that "NONE" is chosen for the compression and that "IBM PC" is chose for the byte order as in Figure 2.10.

Figure 2.9: Saving as a TIFF file.

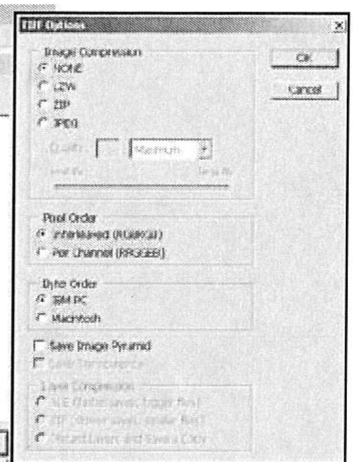


Figure 2.10: Image compression and byte order dialog box.

After the corrected archival master is saved, surrogates may be created according to project goals. If images of a different size or resolution are needed, use the Image Size menu (Image ->Image Size) seen in Figure 2.11.

The image size menu manipulates print size (referred to as document size), pixel dimensions, and/or resolution. In addition, the menu allows for images to be resampled if desired. When the option to resample the image is chosen, the pixel dimensions can be directly changed, and altering the resolution or print size will not affect the other as seen in Figure 2.11. If the option to resample the image is unchecked, the pixel dimensions will no longer be changeable and any change to print size or resolution will inversely affect the other.

Once the image size and resolution has been adjusted, use the SAVE AS option again and choose

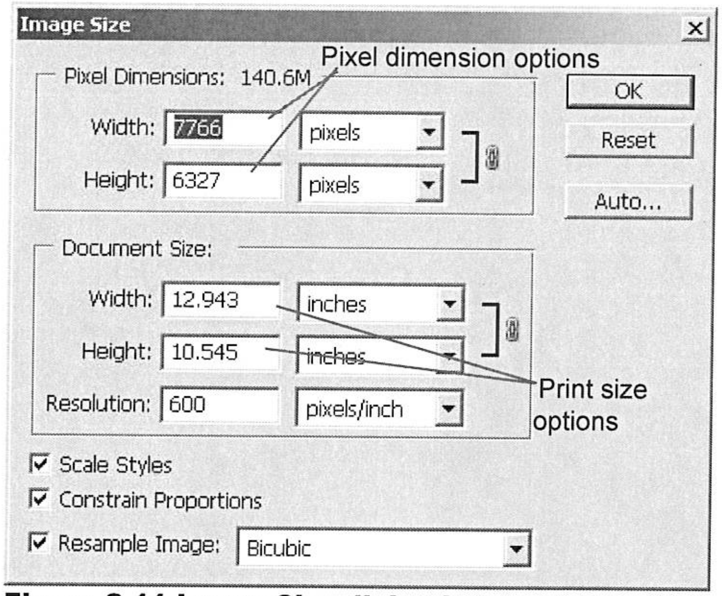


Figure 2.11 Image Size dialog box used for resizing image.

JPEG or GIF for the file format. When the JPEG option is chosen an additional window like that in Figure 2.12 will open. Project guidelines should be used to determine these options, although a quality rating of 5-7 (Medium) and a progressive format option is generally acceptable.

The GIF format also has further options for indexed color and byte order. Generally, Photoshop's default settings for these windows (Figure 2.13) are acceptable. Again project guidelines should determine these options.

Once all of the surrogates are saved work on the image is finished.

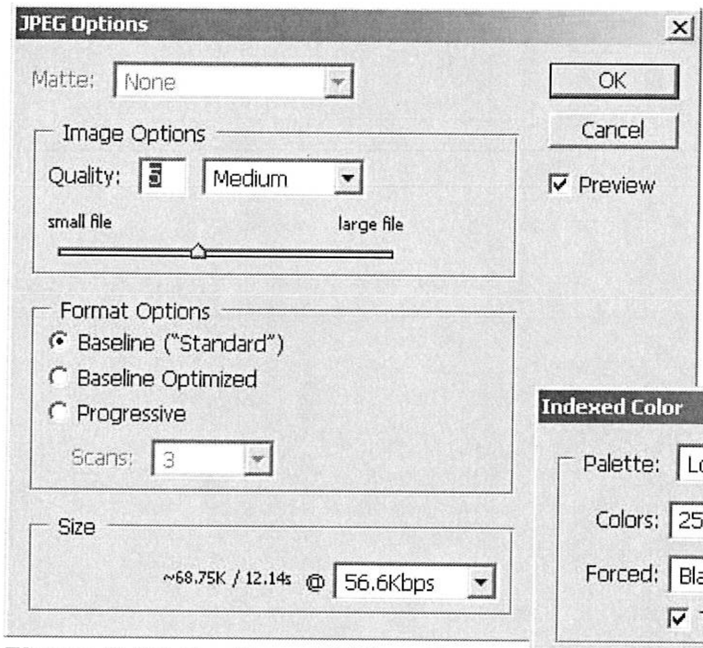


Figure 2.12: Further JPEG options.

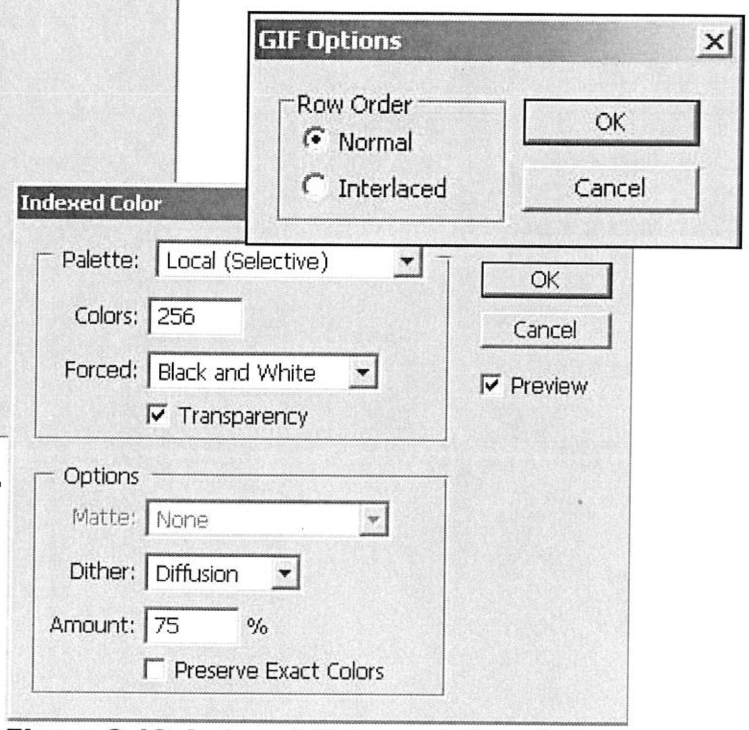


Figure 2.13: Indexed Color and Row Order options for GIF files.

2.5 Postscan: Sharpening

Sharpening an image involves using a special sort of filter in Photoshop. Use this tool sparingly and only on derivative or surrogate files. This adjustment should never be done to an archival master.

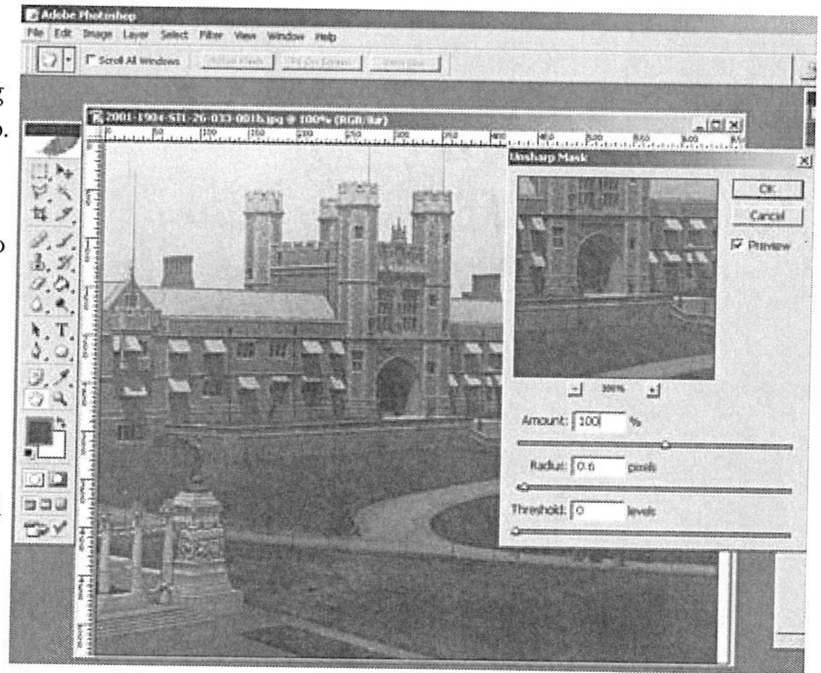


Figure 2.14: Unsharp Mask Filter in Photoshop.

1. Begin by opening the Unsharp Mask tool (Filter -> Sharpen -> Unsharp Mask). Make sure that the "Preview" option is selected in the tool interface so that changes will be represented in the image while they are being made. Although the changes will be seen in the image while the editing is occurring, the image will revert back to its original state if "OK" is not selected in the tool interface when editing is finished.

2. Always start by setting the Amount to 100% and the Threshold to 0.

3. Next set the Radius at a point where some smoothing of the large shapes occurs without losing distinct edges or creating halos and dark lines around the objects. A rule of thumb is to never set the Radius to more than the ppi divided by 200. So if the ppi is 400, do not increase the Radius above 2.

4. Go back to the Amount. This can be increased as much as is desired, although it is rarely necessary to exceed 200%. Increase the Amount until maximum distinctness has been reached without introducing too much noise or coarseness. Some noise can be filtered out with the Threshold tool, but not all.

5. Finally use the Threshold settings to smooth those areas where noise has been introduced — areas that should be of a similar tone, but which have imperfections that have been affected by the sharpening.

The final result is subtle in this instance, but the sharpening has defined some of the fine detail, especially around the tops of the towers and windows in this image, as can be seen in the comparison of Figures 2.15 and 2.16.

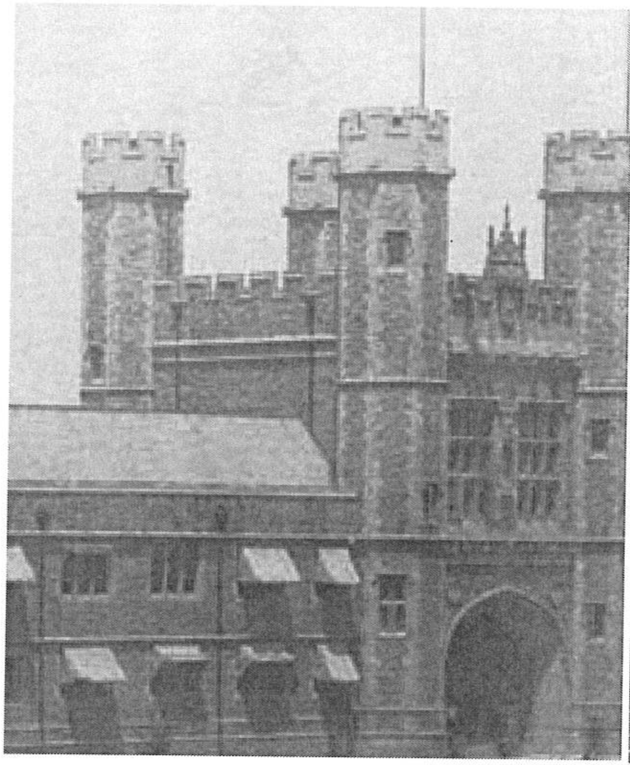


Figure 2.15: Unsharpened image.

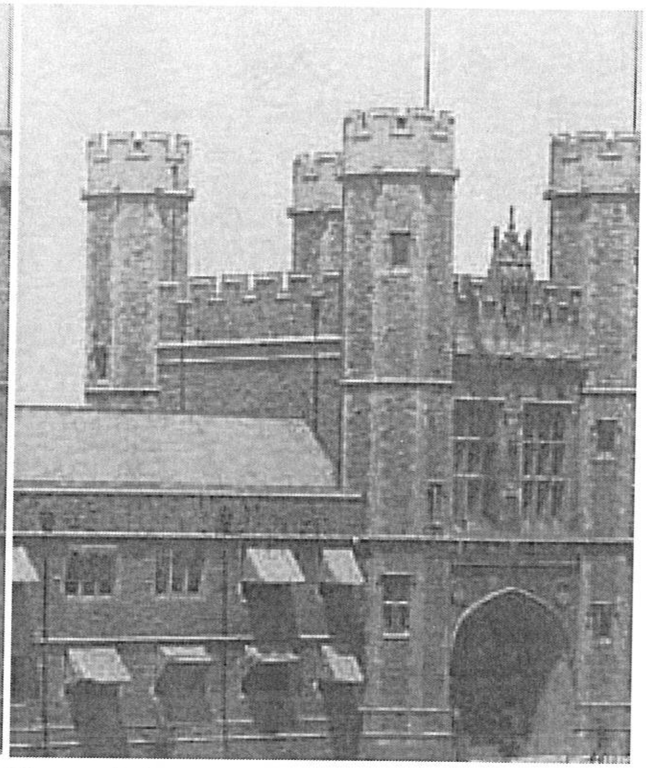


Figure 2.16: Sharpened image.

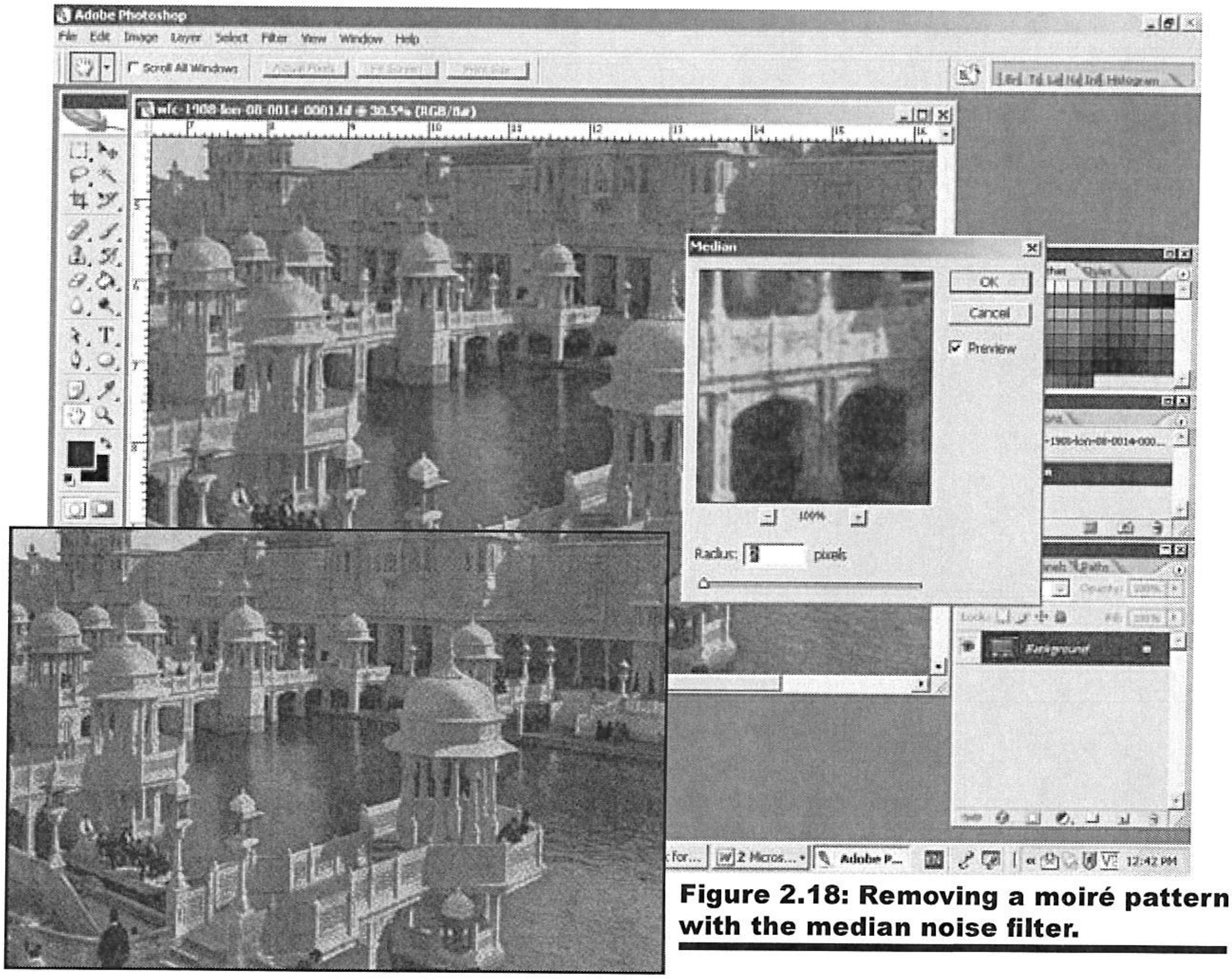


Figure 2.18: Removing a moiré pattern with the median noise filter.

Figure 2.17: (inset) Original image showing a moiré patern.

2.6 Postscan: Removing Moiré Patterns

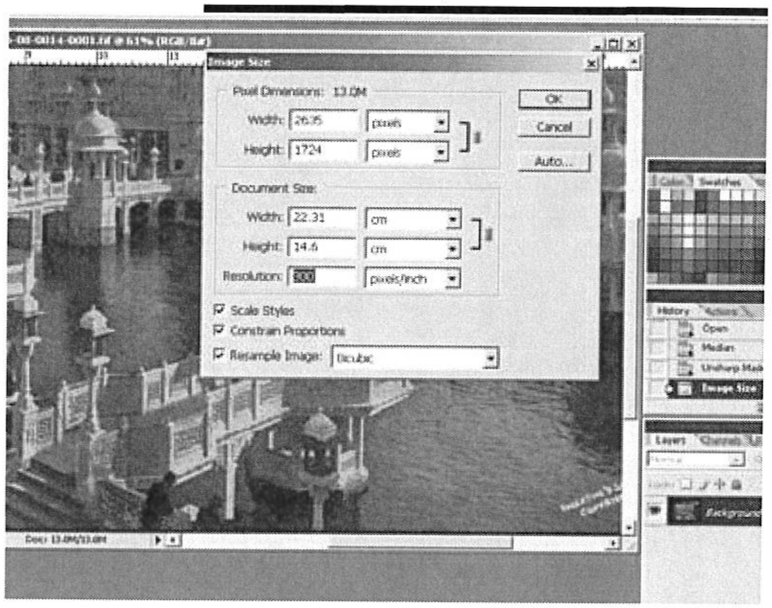


Figure 2.19: Resizing an image after removing moire pattern.

The majority of the action taken for this adjustment should be done postscan, but is dependent on the original scan resolution. Since this type of adjustment involves blurring image details slightly, the resolution of the initial scan should ideally be 150% – 200% of what is needed for the adjusted copy. For example, if an adjusted copy is needed for a 300 dpi access version, doing the original scan at 600 ppi will provide enough image detail to withstand the blurring and sharpening. Most likely, creating an archival master image will require this level of resolution anyway.

1. After the original scan is made, save a copy as the master file and open the image in Photoshop.

2. Resample the image to the desired print size, but keep the resolution the same. Save the new access copy with a different file name.

3. View the image at the Print Size (View -> Print Size).

4. Open the "Median" filter (Filter -> Noise -> Median) from the Photoshop menu. Select a Radius between 1 and 3 (Figure 2.18). The higher the original resolution, the higher this setting may be. Some smoothing of the dot pattern should be seen without totally losing the image details. There may still be some residual moiré effect seen while the tool is open. This will probably disappear once the adjustment is made. If necessary, use the History palette to undo the change and try again with a different Radius until the desired effect is achieved.

5. Next, Sharpen the image as described in the directions in section 2.5.

6. Finally, change the resolution to the desired final resolution (Figure 2.19). Be sure to check the quality of the image by viewing at the print size again. If the results are not satisfactory, use the History pallete to go back and try the median noise and Unsharp Mask filters again.

7. Save the image again, making sure you are saving a copy. This image should appear to be an acceptable surrogate at this print size and resolution. It is not a replacement for the master image.

Digital Images at the University of Maryland Libraries

As these guidelines are used, it is important to remember the numerous resources available to help guide project development within the digital collections infrastructure at the University of Maryland Libraries.

In addition to these guides, please consult the *Best Practices for Digital Collections at the UM Libraries* for a discussion of the digital project lifecycle, standards for digital files, and policies and procedures for establishing and developing digital collections. Direct guidance in the development of digitization goals, workflows, and training may be discussed with the staff of Digital Collections and Research and the Special Collections Digital Initiatives Team. Consulting these resources will ensure that digitization efforts are compatible with the framework for digital collections at the UM Libraries, but also that they meet established standards for quality and preservation. Digitized files created under the guidelines set forth in these resources can then be added to the Libraries' digital repository with little or no duplication of effort and will make a lasting contribution to the intellectual resources available to all users through the UM' Libraries' digital collections.