Why 16 bit?

Color Folio
The Finest in Fine Art Digital Printing

Overview

The digital imaging world is moving increasingly toward full support of a 16 bit workflow, and with good reason. Color Folio is now offering this capability to our clients with the advent of full 16 bit scanning output. This paper will explain what 16 bit files are and why they are important.

What Is Bit Depth?

Every value in a digital file is represented by a string of 1's and 0's. This is the binary number system used by all computers. How many of these you string in a row to represent a single value determines the range of possible values. For example, if the string consists of a single 1 or 0, it can have only two possible values: 1 or 0. If the string contains 8 1's or 0's, there can be 256 possible values represented by that string, And if the string contains 16 1's or 0's, it can represent 65,536 values!

Most digital images today are so-called 8 bit files —this means that each value in the file is represented by a string of 8 1's and 0's and can range from 0 to 255 (all 0's would be 0 while all 1's would be 255). When examining a digital file in an imaging program such as Photoshop you will see that each pixel has one of these values (0 - 255). A histogram is a representation of how many pixels have each of these values - it is essentially a picture of "buckets" ranging in value from 0 to 255. The height of each part of the histogram shows you relatively how many pixels have that value versus the value of other pixels.

People often confuse bit depth with either resolution or dynamic range, both of which are quite distinct. Resolution determines how many pixel values occupy a given square inch. A 5000dpi scan is sampling 5000 x 5000 times per square inch. This says nothing about what values those pixels may have. Dynamic range is a measure of the difference between the lightest and darkest areas on the film. A good metaphor is a staircase - dynamic range shows how long the staircase is but does not tell you how many steps there are in the staircase (each step may have a different size). Bit depth is a measure of how many steps there are in the staircase. In the case of an 8 bit file, there are 256 steps in the staircase (regardless of how long the staircase actually is). In the case of a 16 bit file, there would be over 65,000 steps in the staircase. In other words, each step represents a smaller, finer portion of the entire staircase.

In a histogram of a 16 bit file, even though it is not visible as such, there are 65,536 buckets represented. In fact, each bucket in an 8 bit file histogram breaks down itself into 256 buckets each of which representing a distinct value that a pixel can have.

Currently most output devices require an 8 bit file. If you start with a 16 bit file and convert it to 8 bits, what happens is that the contents of each 256 buckets are consolidated into a single bucket in the 8 bit file. Why this is important will become clear soon.

Where to Get 16 bit Files

Digital files start out as film and are scanned to create the initial digital file. In recent years, scanners have improved at what bit depth they sample the information. Most now sample values that have at least a 12 bit value and many go all the way up to 16 bits. The Heidelberg Tango™ scanner used by Color Folio scans in full 16 bit mode. This means that each pixel sampled has one of those 65, 536 possible values. Clearly a very sophisticated degree of distinction can be obtained between different samples!

Many scanners, however, including the Tango until recently, would truncate all the values in the file back to only 8 bits upon saving the scan out to disk. This was done primarily because very few applications had any ability to do anything with 16 bit files. That is changing, particularly driven by great improvements in the most common imaging application, Adobe Photoshop, which now supports 16 bit file manipulation.

There are other scanners that will now scan in full 16 bit mode and output all 16 bits into your file. The new software interface to the Tango, known as Newcolor, allows such files to be saved and Color Folio is now offering this service via the Newcolor software.

Pros and Cons of 16 bit Files

Is a 16 bit workflow for you? First lets examine the pros and cons of 16 bit imaging and then we can discuss some ways to consider the question.

First, there are a small number of downsides. Because each pixel value requires 16 instead of 8 bits of storage, your file size at the same resolution will be twice as large. For example, a 5000dpi scan of a 35mm slide at 8 bits is about 100mb; at 16 bits it is about 200mb. Since most scans are priced based on file size, it is typical for the larger 16 bit scan to be more expensive. Finally, since there are things you may want to do to your file in Photoshop that are not possible in 16 bits, you may need to keep two copies of the file the 16 bit scan file and an 8 bit Photoshop version. This will require additional disk space.

The advantages of 16 bit workflows have to do with the great increase in the number of possible values each pixel has. As you make edits to a file in Photoshop, the pixel values are changed. The histogram is redistributed. As this occurs, and especially if the changes made a more than minor, two situations may arise. First, some of the buckets may no longer have any pixels with that value- the bucket becomes depopulated, resulting in a gap in the histogram. The other scenario is that more and more values that used to be distinct, existing in different buckets, now are the same, creating a larger spike in a given bucket of the histogram.

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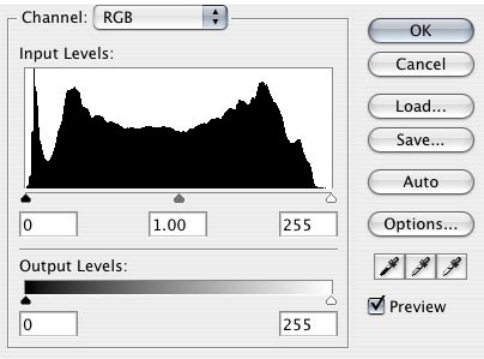
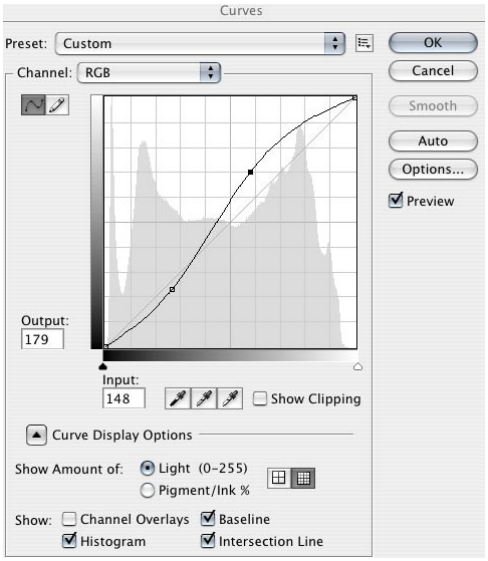
The effect of these changes may be that gaps in the histogram may result in posterization and the increase in spikes can cause reduction in detail in the image (detail in a digital file is a result of distinction of pixel values). Posterization occurs when the gap in adjacent pixel values is too great for the level of smoothness needed. For example, in a gradient area such as a sky, each value should be very close to its neighbor in order to maintain the smooth pixel by pixel transition needed. If editing the file pushes pixels around enough to depopulate enough adjacent buckets in the histogram, you may start seeing “jumps” in value in your smooth gradient areas. Increase in spikes in the histogram may result in blocking up of areas that previously had distinct values but that now consist of pixels all containing the same value.

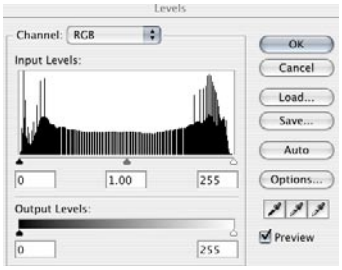
To demonstrate this graphically we took a raw 16 bit scan and opened Levels to view a histogram of the file:



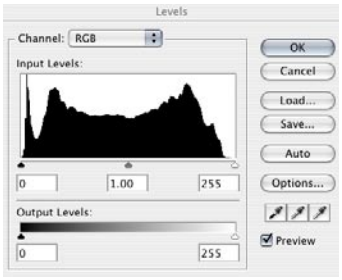
Note that the histogram is currently smooth. We made a copy of the file and converted it to an 8 bit file. We then applied the following curve to both files. This curve represents a fairly good size contrast move, but nothing that is all that unusual.



Here are the two resulting histograms:



8 bit file



16 bit file

Note that the 16 bit hisogram is still as smooth as in the original file, while the 8 bit file histogram not only is exhibiting numerous gaps, but also now has some spikes in the highlight areas that represent a reduction in detail.

Whether these changes in the histogram are sufficient to produce a print that is of lower visual quality depends on many factors. Certainly gaps and spikes in histograms are not inherently bad and are fairly inevitable if you make any edits to speak of to the file. If the gaps occur in regions that contain smooth gradient transitions, it is more likely that they will create visible artifacts.

Even if a print made with today’s output technology does not make visible the differences, it is inevitable that manufacturers will begin to take advantage of the proliferation of 16 bit files by making their printers capable of outputting them without conversion to 8 bit. By converting to a 16 bit workflow now, you will be ready for the time when this is a reality.

Summary

Bit depth, along with resolution, dynamic range and noise ratios, are some of the determinants of digital file quality. Starting with digital files that achieve the highest calibre in each of these categories gives you the best chance of making the finest prints from your film. 16 bit depth can make a difference to your print results and ensures you archive your film in an optimal way.