

# LA CONTROVERSE 16-bit contre 8-bit : l'article final de Dan Margulis (janvier 2005)

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## A post from Dan "The Man" Margulis

\*\*\*This is a post from the man, from the color theory list. Posted with his permission (post #12379 on the color theory list)\*\*\*

Last month, it appeared that some the basics were finally being agreed upon as to some of the advantages or lack thereof in color-correcting 16-bit files vs. 8-bit files. This topic that has wasted far more time than it could possibly merit over the last half-decade. Because there was a lot of posturing that masked the essential agreement, I suggested that we stop the thread, and I promised that at a later time I would post a fuller response.

I'd like to start from scratch and explain what the basic principles are, why the debate went on so long, and what it teaches us for the future. I do not believe this is a topic significant enough for a magazine article, but this post is article-length, and is therefore divided into three parts plus an appendix. I intend this to be my last word on the subject until the next edition of Professional Photoshop, unless there are some new developments from images I am now studying.

## Part I

### DEFINITION

A bit is the smallest addressable part of a computer's memory. It can be seen as either 0 or 1, either on or off, either yes or no. Each bit therefore has two possible states. Two bits taken as a pair have four possible states. Three bits have eight, four bits 16, and so on, with the number of possibilities doubling every time a bit is added.

Ever since the advent of digital color correction in the early 1980s, it has been standard to devote 8 bits of computer information to describe a single pixel in a single channel. This gives a total of 256 possibilities. In three-channel colorspaces like RGB, 24 bits (8x3) are required to fully define the pixel's color, meaning that there can be 16,777,216 (256x256x256) possible colors for a given pixel.

Nobody can see that many colors. Even the most optimistic estimates--and that's the side you find me on--say that humans can only perceive a little more than a million colors, and most experts put the figure considerably lower than that. Nevertheless, some believe that it makes sense to try to define more colors. Some digital cameras try to record 10-bit (1,024 possible values per channel, a billion possible colors). Modern drum scanners try for 12-bit (4,096 values, 69 billion possible colors). Whether these devices are accurate to that level of precision is very doubtful.

In the mid-1990s, Photoshop introduced limited support for 16-bit files-- 65,536 values per channel, 281 trillion possible colors. There was no intermediate level. If you had a 10-bit file and wanted to get it into Photoshop, you had to decide whether to bloat it by making it 16-bit or compress it by making it 8-bit. Also, few important commands other than curves would work on a 16-bit file. We could not even make a layered file in 16-bit. As time went on more support was added, and today almost anything we can do in 8-bit we can do in 16-bit.

## **THE ISSUE**

The question before us is not whether to capture in 16-bit, store in 16-bit, or output in 16-bit. The only issue is, first, is there any advantage in *editing* files in 16-bit rather than 8-bit, and if there is, it is so enormous as to constitute a "night and day difference" or to justify the statement that anyone who does not edit in 16-bit is a "recreational, rather than professional" user of Photoshop.

16-bit files are twice as large as 8-bit files. They take longer to store and to back up and require more disk space. Also, if the file size is large, it may take Photoshop much longer to perform edits. Plus, most output devices and many layout programs won't accept 16-bit files, so we have to go to the trouble of converting them to 8-bit eventually anyway.

For some, this isn't an issue. They process a limited number of images in studio and, taking advantage of today's low prices, they have an infinite amount of storage space. For others, like newspaper photographers on deadline, doubling the file size would be so onerous as to be out of the question even if there was a undeniable quality gain associated with it. For everyone else, the doubled file size is an inconvenience to some degree. The question must be whether we gain any benefit, and if so, what, because it's possible we might want to use 16-bit some of the time and not others.

When someone advocates doing something inconvenient, whether converting to LAB, or using Camera Raw, or doubling one's file size, or putting 15 layers on a file, it's up to that person to make a compelling case for it. It isn't up to you, me, or anybody else to show that it's *wrong* to do it. The reason that the subject has refused to die is that the advocates of 16-bit editing claim exemption from this rule: they take the position that whatever they recommend, whether it's 16-bit editing or wearing garlic around the neck while writing curves, must be taken as gospel and that they have no responsibility to back up what they say.

## **AREAS WHERE EVERYONE AGREES**

Nobody AFAIK has ever doubted the following.

Extra bits are valuable in editing computer-generated graphics, especially those that include gradients, or with image areas that are so heavily retouched that they are essentially computer-generated as opposed to photographic.

Scanners, digital cameras, and Camera Raw all operate natively with more than eight bits. As there's no way to make them operate any other way, the question of whether they *could* operate effectively with fewer bits is irrelevant.

Certain scanners and certain camera software do not generate 8-bit files correctly. Therefore, where possible, these files should be brought into Photoshop in 16-bit, and converted to 8-bit at a later time.

Most people who handle lots of images have from time to time been burned because they failed to save a copy of the original, untouched image. People crop the image or rez it down only to discover that the extra information comes in handy a year later. The chances of a bug in Photoshop or the OS inadvertently damaging a file when it is resaved are extremely small, but they are not zero. That alone is a good reason to save a copy of the original 16-bit file.

16-bit does no real-world harm other than the extra space and computing time it requires.

### **THE INITIAL WILD CLAIMS**

While nobody has ever argued that people who are comfortable using 16-bit for correction should stop doing it, the same is emphatically not true of 8-bit users. Starting in 1999, a slew of self-appointed experts, largely but not exclusively Andrew Rodney and his business partners, began to attack anyone who didn't use 16-bit for *all* editing. The rhetoric they used was apocalyptic. Editing in 8-bit was "amateurish". It was "highly critical" to edit in 16-bit all the time. Those ignorant enough to edit in 8-bit proved themselves to be "recreational, rather than professional" users of Photoshop.

Early on, a number of users questioned this, stating that they had compared the two approaches found little difference in the results. Instead of accepting the possibility that they might be mistaken, the 16-bit advocates dug in their heels. I quoted the following from a single 2001 thread, where a squadron of "experts" were berating their challengers. This is not a single speaker, but a group of them, separated by ellipses :

*16 bit capability is critical during all aspects of tone compression...*

*The difference CAN be seen in the final output very easily. Most definitely on the printed page, especially when using high-quality halftoning and even more so to a film recorder...*

*It's very easy to see that substantial color & tone editing will eventually result in data loss and banding...*

*If it means the difference between taking a 16-bit image capture and editing that to the final image and taking that same image in only 8-bit and editing that to the final image then there is a difference like between the day and the night...*

*Yes, if a histogram full of holes has no impact on final output, then throw away the graphs and just get on with the print run. However, all of us have Real World Output showing the superiority of superior data acquisition...*

*My advice? Take the information you've read here to the bank. Stop doubting and start applying what you've learned here...If you really start out with a RAW image in high-bit form and a raw image downsampled to 8 bits, the difference really is night and day. ...*

*it's totally obvious to anyone who looks that it's very advantageous to do the big moves on high-bit data.*

Nobody offered a single real-world image to show this enormous difference. It was all histograms and gradients, gradients and histograms.

### **THE "CHALLENGE"**

The type of color correction I teach does not depend on bit depth. The methods work equally well whether you choose to use 8-bit or 16-bit. I have never written an article or a column about bit depth. I don't even mention the topic in my classes.

There are around ten pages of Professional Photoshop that discuss bit depth and around five pages of Photoshop LAB Color. They are there is not because they are necessary to my message in any way, but because the advocates of 16-bit editing were so forceful in their denunciations of anyone not using their methods that I kept getting hit with the question, both on this list and elsewhere. [http://www.ledet.com/margulis/ACT\\_postings/ColorCorrection/ColorCorrection.htm](http://www.ledet.com/margulis/ACT_postings/ColorCorrection/ColorCorrection.htm) there are several archived threads on this topic dating from 1999. The only thing that I could answer was that I have nothing against others using 16-bit, and use it myself in dealing with computer-generated graphics and in very specialized cases with color photographs. However, AFAIK there are no real-world circumstances under which a non-expert would find it beneficial for editing color photographs.

Before putting anything in my own books, I try to verify that there isn't something unusual about my own files that causes me to draw an incorrect conclusion. I therefore posted a request for people who thought that they could demonstrate an editing superiority for 16-bit to arrange to send me files for testing. As my own testing (see Part II, "Where 16-Bit Can Be Better") had already established that a grayscale file could conceivably show an advantage either for 16-bit or (more commonly) for 8-bit editing, I specified color photographs only, in one of the four standard Photoshop RGB definitions

Around a dozen people have since responded between 2001 and now. They put together packages containing proofs and often several different versions of corrections. Over a period of a full week in 2002, I analyzed image after image trying to find any circumstances under which 16-bit editing would give superior results.

Finding none, in Professional Photoshop Fourth Edition, I published almost ten pages of comparisons, because to illustrate the points, pictures have to be fairly large. Six full pages were devoted to showing images at various magnifications. Because the 16-bit advocates had retreated to a position of claiming that the difference was only critical when the corrections were large ones, the examples I showed ranged from large to inconceivably huge, in one case taking a picture that was so flat that it was unrecognizable for subject and correcting it into something that could be mistaken for professional work. I printed each image at high magnification, including some individual channels. They were printed without identification and readers were invited to guess which was which. I particularly chose images that would be the most prone to the sort of banding that the 16-bit advocates claimed would happen.

Every person who has ever submitted files to me has agreed with my assessments of image quality. Certain people have had procedural mistakes that I pointed out, and they have always agreed that my objections were correct. In the cases where I am stating that there was a

qualitative difference when done in a certain way but not in another. I have shown the results to the person submitting the files and they have always agreed with my findings.

Similar independent testing was subsequently performed by Jim Rich. The main difference between his testing and mine was that Jim's testing involved real-world corrections of images, in that his corrections, although severe, might actually be seen on an everyday basis. Mine, on the other hand, were intentionally set up to be far more demanding than any real-world scenario would ever entail. Anybody having to deal with the type of challenges that I published has many more serious workflow problems than bit depth.

Jim's testing, which was also independently reviewed by experts, got the same results. Since that time, around a dozen people have performed similar tests, trying to find any real-world scenario in which 16-bit editing of color photographs might produce an advantage, however trivial, over doing the same thing in 8-bit. Everyone has come up empty.

In my LAB book, I had one further example, in trying to dispose of a similar myth. In the mid-1990s, one of the same people who now fiercely defends 16-bit editing was even more fiercely opposed to the use of LAB. He asserted that the very conversion from RGB to LAB to do the editing caused "catastrophic damage" to the image. This opinion was, of course, based on analysis of histograms and gradients. In response, in a 1997 book, I showed side-by-side images, one of which had been converted back and forth between LAB and RGB 75 times. No difference, of course. Nevertheless, the myth persisted, and I would several times a year get questions about the supposed damage. So, in the LAB book, I did another such example, 25 times back and forth. I compared it mathematically to other conversions and demonstrated that the variation between the RGB>LAB>RGB and the original RGB version was less than that between many RGB to RGB conversions.

Shortly after announcing the "catastrophic damage" theory and finding that there was no damage at all even after multiple conversions, the theorists changed their theory. The catastrophe, they opined, only occurred the *first* time that a file was converted; subsequent conversions of the same file would be harmless. But, if at some other point in the correction, there would be for some reason another conversion to LAB, *that* would be a catastrophe. This was similar to one of the changes in their 16-bit theory. Originally, it was "highly critical" to do all edits in 16-bit. Then, it was changed to "big changes". When it became clear that this theory didn't hold up either, it was changed to "big changes done over a series of smaller changes."

Therefore, in total disgust, I spent five pages of the LAB book showing large-size, magnified comparisons not of two variants, but of four, of each of two different images. The images were specifically chosen because they had the type of smooth areas that supposedly cause disaster in 8-bit editing and in conversions to and from LAB. One was a 16-bit digicam capture, the other 16-bit scanned film. They were compressed into a small 16-bit range, which is far more challenging for the subsequent edit than starting with an original limited-range capture.

To these images, I applied not one or two big corrections but, in accord, with the theory, seven of them. These were done in RGB. I did the test once in 16-bit, and once in 8-bit. But then I repeated the tests with a twist--after each of the seven moves, I converted unnecessarily to LAB

and back again. Therefore, between the most politically correct of the four variants (16-bit all the way, no conversions) and the least (8-bit all the way plus a conversion to LAB after each move) there were seven night-and-day, totally-obvious-to- anyone-who-looks corrections *plus* seven catastrophic-damage conversions.

Nobody could tell which was which even at high magnifications.

## Part II

### WHERE 16-BIT CAN BE BETTER

A 16-bit file can have very minute differences between pixels--1/256th of the minimum difference in an 8-bit file. Anything that small will have no impact on the final reproduction--no possible sequence of editing events could ever create a variation that anybody could see. The maximum initial difference between a pixel of an 8-bit and a 16-bit file would be slightly less than half a level. That is, in a 16-bit file there might be a value of 128.49, which would be treated as a value of 128.00 in 8-bit. That half-level difference won't do anything, either, *unless* some unlikely sequence of commands drives it much, much further away from where it would be if it were an 8-bit file.

For technical reasons that will be discussed later (see What the Extra Bits Actually Do, Part III), if you look hard enough and at a high enough magnification, the 16-bit edit always looks marginally smoother and the 8-bit more active. To date, I know of four types of natural photographs that, if edited to an extreme, show differences large enough for people to prefer one or the other. (There are also some times in retouching and image conversions where working in 16-bit helps, but they are so esoteric that I have rarely written about them.)

- (1) If we apply massive edits to a grayscale file, the difference between an 8-bit and a 16-bit correction may become noticeable. The 16-bit version would be preferred if the image featured areas where smoothness is desirable, like skies; the 8-bit when the subject is full of detail. In my testing, even with very big grayscale edits, well over half of the images showed no difference. Of the others, the result of 8-bit editing was preferred roughly twice as often as 16-bit edits. But definitely 16-bit editing got better results in certain images. The reason that this does not carry over into color images is that when three channels are superimposed on one another any variation in one is less visible. Similar massive edits to the RGB files that were the ancestors of the grayscale files showed no difference of any consequence.
- (2) Early in my testing, one list member provided a demonstration based on applying the same edits to one 16-bit and one 8-bit file, both generated by a scanner from a single scan. I verified that when the edits were applied the 8-bit file looked distinctly worse. However, when the tests were repeated on a copy of the 16-bit file that had been converted into 8-bit not by the scanner but in Photoshop, there was no difference in quality. I communicated this finding to the list in 2001 and recommended that people take 16-bit files from scanners where possible.
- (3) A second user provided a similar exercise where edits were applied to 16-bit and 8-bit files generated in Canon acquire software from the same digital capture. (The original had

deliberately been acquired incorrectly in order to make the differences more apparent, which disqualifies it as a real-world example, but in view of the interesting nature of the problem I followed through with the testing.) Again, I verified that there was a quality loss by editing the user's 8-bit file, again I retested by converting his 16-bit file to 8-bit in Photoshop, and editing that. As with Example #2 there was now no longer a quality difference, so I recommended to the list that we avoid taking 8-bit files directly from a camera package when a 16-bit file is available. I do not know whether the same problem exists in Camera Raw but I will be testing it in coming months.

- (4) In 2005, a third user provided a Camera Raw file of a scene of a city at night. He sabotaged the image by moving the exposure slider within Camera Raw all the way to the left in spite of the fact that the image was already too dark. Then, he acquired the image in ProPhoto RGB, an ultra-wide gamut RGB definition that is rarely used in professional work. The image contained a large area of sky. Applying the drastic curves that were needed to lighten the image to the 16-bit file resulted in a perceptibly smoother and more attractive sky than the one done by converting the file to 8-bit in Photoshop and applying the same curves there. When the same image was captured with the same sabotage in Camera Raw into either of the RGB definitions that most of us use--the narrow-gamut sRGB or the wide-gamut Adobe RGB--there was no significant difference between correcting in 8-bit or 16-bit.

## THE RETREAT

Ever since the initial assertions that 16-bit editing would create an enormous difference, its proponents have been in full retreat as users have asked them again and again for any example to support the notion. They have provided a blizzard of gradients and histograms, but never a real image. One author's idea of illustrating the concept was to compare an *original* image to one that had been edited in 8-bit and then showing the histogram. In a second book, he compared reasonable editing in Camera Raw (which is 16-bit) with idiotic editing in 8-bit Photoshop, in each case claiming that it showed the superiority of 16-bit editing.

In fairness, the demand for images placed the advocates in a difficult position.

There is no reason to doubt that they actually believed their original wild claims were true; as has been made abundantly clear since, they never bothered to run tests before making them. By the time they learned that there was serious doubt that there was any 16-bit benefit at all, let alone a night and day difference, they had already begun to promote seminars about the benefits of the 16-bit workflow. Furthermore, Adobe, largely at their suggestion, had begun to add 16-bit capabilities to Photoshop which were being heavily hyped. As many of these advocates take money or other support from Adobe, it would have been exceedingly awkward if they had abandoned the you-are-not-a-professional-if-you-don't-use-16-bit line.

Since they could not abandon their position but could not produce anything to back it up, they resorted to smokescreens. The usual method was personal attacks on me. They repeatedly referred to some mysterious "agenda" of mine. They called me lots of names, but never could get around to showing what the people were asking for. They asserted that I said 16-bit was worthless under all circumstances and presented gradient after histogram to prove that it wasn't. They spent scores of hours telling users that they were "too busy" to prepare demonstration

images that could have been made very quickly if the difference was even a tenth as critical as what they were touting. They constantly tried to evade responsibility by saying that the burden was on me to prove that 16-bit doesn't have advantages, as if *I* were the one who was saying that anyone who didn't work my way was unprofessional and *they* were the ones who were tolerating either way.

One of the more prominent advocates, Bruce Lindbloom, was so frustrated by his inability to produce a persuasive image that he posted a web page that accused me of sabotaging my 16-bit images before testing them. Also, he asserted that I kept my results private and that nobody else could verify them. Both statements are categorically false, and Lindbloom knew that they were false when he posted them. 16-bit advocates Andrew Rodney and, to a lesser extent, Bruce Fraser, both of whom are well aware that the Lindbloom page is a crock from the word go, nevertheless repeatedly post links to it, hoping that if they post the falsehood enough times, it will magically become true.

The gyrations that these advocates went through to explain why they could not produce even a single real image that would support the notion that 16-bit editing was "highly critical", would produce a "night and day difference", and so forth are so remarkable that they are excerpted at length in Part IV.

This list did get a glimpse of the rationale from Jeff Schewe in 2002, in a thread that is posted in our archives. He defended his assertion that those using 8-bit are "recreational, rather than professional" users of Photoshop as follows (note: Jeff frequently uses ellipses [ . . . ] in his messages; in the one case where I have deleted an extraneous section of the message, I use \*\*\*):

*"Nope. . . Dan and the rest of you are welcome to continue scanning in 8 bits and doing whatever you want to do to your images. . . but if you want absolute total control over tone and color without the risk of breaking the image somewhere down the road. . . you better learn to edit in 16 bits. [\*\*\*] And yes, I'll stand by the line 'recreational' if you squander and waste your data bits just getting an image tone/color corrected in 8 bit. . . cause if you do that, you're working with considerably less than 8 bits/channel and deserve the banding you are likely to incur."*

I replied,

*"Rather than continuing to post the same defensive bluster to every group credulous enough to listen, it must be a better use of your time to produce even one image that demonstrates the point. After all, this is supposed to be critical, night and day, the difference between professional and recreational imaging. If an image exists that shows such a dramatic difference, why not show it, rather than just make claims?"*

The evidence Jeff offered in response was,

*"Pretty much all of my work the last 5 years was scanned in 16 bit for initial tone & color correction. You are welcome to look at my work and see for yourself, no banding. . . even after hours of editing and extreme manipulations. I'll let my work speak for itself."*



Within a year, however, others had backed off the original claims. The new emphasis was on "flexibility for the future." The night and day differences were no longer found in really big edits, but only in ones with multiple big edits. We were cautioned that, even if 8-bit is sufficient now, new types of output devices might arise that would require more bits. The ad hominem attacks on me and my purported motivations continued whenever users asked on-line for specific images.

By 2004 the embarrassment was such that the protagonists began to deny ever having made any of the apocalyptic statements. In November, Andrew Rodney posted the following astonishing statement to this list:

*"And no I've not seen any text that says '16-bit is absolutely critical, creates a night and day difference, that anyone who doesn't do it is an amateur, etc., etc'. It's simply a reflection of math and physics."*

When Ric Cohn pointed out that Andrew's own business partners had frequently used precisely those words, the following day Andrew denied having denied it. Thereupon I produced Andrew's original denial--and he denied ever denying he had denied it. And throughout the rest of the thread he resumed the position that nobody had ever said such things. And held to it, even after the quotes were posted.

Earlier this year, on the ColorSync list, of which I am a member but don't normally participate, Bruce Fraser once again took shots at my motivations when the list turned to the bit depth topic. He wrote,

*"What Dan's tedious and fundamentally specious arguments deliberately miss is that the need for greater bit depth has absolutely nothing to do with reproduction and everything to do with editability."*

At that point I entered the thread to point out that I did not miss that point and that on the contrary, the files that I had been testing were edited beyond all recognition, beyond any possible claim of real-world practice. And I pointed out how many other people had performed similar tests with the same results, and again asked why he could not produce any images to back up his claims of a "night and day difference" that was "totally obvious to anyone who looks".

Bruce denied having ever said these things, whereupon I produced the original files where he did say them. After further exchanges in which he waffled somewhat on these phrases, I asked pointblank whether he had ever personally run tests of 8-bit editing vs. 16-bit editing, before or after having laid down these ukases about how the difference would be night and day. He refused to answer. After being further pressed, he stated that it would be a waste of time because it was obvious that the 16-bit would look much better (if you don't believe he said this, don't take my word for it, go to Part IV). And, having refused to accept the possibility that something he hadn't tested might not be true, he ended with a typical slur: "My personal opinion is that this is a manufactured controversy--I decline to speculate on the motivation of those who have manufactured it--and I'm utterly disinclined to waste my time arguing the point when I have better things to do with it."

In many of these threads, other users have chimed in claiming that they are positive from first-hand knowledge that 16-bit editing avoids problems of banding. I'm aware of around thirty such posts, including a couple to this list.

In about a dozen cases, I've gone off-line to ask these people how they are so sure. Without exception, they have never performed any testing--it's all a hunch. They, like Jeff and Bruce, merely are supremely confident that their work would show banding or other artifacting if they did it in 8-bit. But they've never tried to do the same things to 8-bit files that they do to their 16-bit files, so they can't know for sure, and they refuse to accept the word of others who *have* performed such tests.

The people who have doubted that there is a night-and-day difference between 16-bit and 8-bit correction, or that correcting in 8-bit is amateurish, have generally said they are willing to be persuaded otherwise by examples, as I am. Some members of the other side take a different tack. It is so obvious to them that their view is right that not only do they require no proof of it, but they state outright that they refuse to accept any proof that it is not. It has been remarked by others that such a position is a religious rather than a rational one, and I agree. The closest analogy I can think of would be to the person who says that it is so obvious that the world is flat that it needs no proof, and that any demonstrations that it is round will be ignored because they can't possibly be right, since it is well known that the world is flat.

It actually gets better. Since that time, Bruce Fraser has, incredibly, announced that direct comparison of 8-bit to 16-bit editing is invalid, and conceded that side-by-side tests will show no advantage for 16-bit. He writes,

*"I've demonstrated many times things that work better in 16-bit than in 8 bit, but Dan has rejected these because they don't fit his narrow criterion of doing exactly the same things to a 16-bit and an 8-bit file, then comparing the results."*

Separately, he clarifies,

*"The major problem with the methodology...is that by making identical edits to the 8-bit and the 16-bit, you're throwing out any benefit the extra bits may bring. They aren't useful unless you DO SOMETHING with them!"*

The extra bits may indeed be useful if you do something, but there's no way of knowing for sure without trying to do the something without them, and seeing if there's a significant difference. A lot of people have done this. The answer they have unanimously come up with is that there is not.

### **Part III**

#### **THE CONSENSUS**

In early September, Andrew Rodney posted his own "real-world" example of 8-bit vs. 16-bit editing. As soon as it appeared, it was dismissed both by me and by Lee Varis because it depended on an exotic RGB definition, the ultra-wide gamut ProPhoto RGB, where the perceived impact of tiny variations is much larger than in the RGB definitions used by almost everyone. Andrew has known for at least five years that I consider testing in such RGBs irrelevant--see "The Attempts to Obfuscate" below.

Even if we were allow Andrew to sneak this image in, it wouldn't show a 16-bit superiority, for two reasons. First, he deliberately chose a zero-threshold sharpening setting for his image to emphasize the differences between his 16-bit and 8-bit versions, when an equivalent setting that required no additional steps was available. To back up the premise that you have found a real-world difference, it's fair to say "I would like to do the following or something equivalent, and I find that there is no way to do so without getting an effect that displeases me." That would have been the case with any of the four examples cited in Part II, "Where 16-Bit Can Be Better". It is, however, fatuous to say, as Andrew does, "Of many possible equivalent settings, I have intentionally chosen the one that displeases me, and now the test fails because I am displeased."

Second, the standard is "totally obvious to anyone who looks," a "night and day difference." Anybody who looked at the four examples cited above would, in my opinion, prefer the 16-bit versions. The only person known to have been shown printed versions of Andrew's samples preferred the 8-bit version. Some areas of Andrew's 16-bit version are better than the 8-bit but larger areas are worse. I think that a jury would rate the two versions as qualitatively equal, but if they did not, I expect they would choose the 8-bit version as better overall.

Andrew's edits were not particularly severe. Conceivably more massive edits would have created a pair of images with differences strong enough for people to have a clear preference for one as opposed to the other. In view of my testing with B/W images, I think it's likely that when there is an actual preference, people would tend to prefer the version corrected in 8-bit. However, there would also be cases where the smoothing effect of 16-bit editing would be preferable. But again, the situation is not real-world. Anyone knowledgeable enough to take advantage of the extra bits would be unlikely to be editing in such an RGB in the first place. And nobody, not even Andrew and his partners, advocates making big edits in an ultra-wide RGB in Photoshop proper. Any move big enough to provoke a visible difference because of bit depth, they would urge making in Camera Raw.

Lee, Andrew, and I all agreed that when the file was put into Adobe RGB rather than ProPhoto RGB, and the same edits, including the zero-threshold sharpening, were applied, there was no significant difference between the 16-bit and 8-bit version. Whereupon Andrew stated,

*"I will admit: If you work with a small(er)gamut space, the need for high bit editing is reduced and possibly a non-issue."*

I think that this face-saving admission is acceptable--that for Adobe RGB and sRGB, the two spaces that we almost all use--editing in 16-bit is no longer highly critical, no longer the distinction between a professional and a recreational user, no longer a matter of night-and-day difference, but rather "possibly a non-issue." In return for Andrew's concession, I cheerfully respond as follows:

*"I categorically recommend against making major edits to photographs in ultra-wide RGB spaces such as Wide Gamut RGB and ProPhoto RGB when any reasonable alternative exists. If you nevertheless insist upon doing so, you should take into account that under such conditions the bit depth of the file may affect quality, so you should be aware of the circumstances in which 8-bit editing may be superior as well as those in which 16-bit may be."*

## THE ATTEMPTS TO OBFUSCATE

Throughout these five years, the 16-bit advocates have been trying to deflect attention from the basics, which are that they bullied and berated users, calling them ignorant and unprofessional, all because these users did not use an inconvenient workflow that has never been shown to be of any use whatsoever.

The challenge is a simple one: to take any color photograph that might conceivably be used in a professional setting, operate on it in any way that a person, even an incompetent one, might try, and demonstrate a clear superiority for 16-bit editing of that particular image. I do not say that no such image could possibly exist. I do say that we have not seen one yet, and a lot of people, including me, have tried hard to find one.

The terms of the challenge are extraordinarily permissive, and the 16-bit advocates have resorted to extraordinary whitewashing to cover up the fact that they can't meet them. They keep trying to sneak in obviously inapplicable stuff; when everyone laughs at it they accuse me of "changing the rules" and click their tongues and say, "see? No matter how hard we try, our stuff is always rejected on a technicality! Clearly there's no image in the world that Dan would ever accept!"

We saw this on the list last year. A member posted as an example a Photoshop file consisting of no more than small blue area with noise. He asserted that this was a picture of a "sky." There was no way of verifying this as there were no clouds or other detail that might identify it as a sky; no way of knowing that it wasn't computer-generated, for that matter. I said that it is somewhat difficult to accept as a "real-world photograph" something that an independent viewer can't identify as a photograph at all, let alone what it's a photograph *of*. Andrew Rodney immediately went ballistic, again accusing me of changing the rules and stating that this proved that I would never accept any image as being real-world.

Similarly, the "real-world" corrections consisted of seven pairs of drastic actions, each designed to reverse the other. Again, based on my assertion that there was not the slightest chance that anyone would ever be stoned enough to *dream* of doing something as crazy as that in the real world, Andrew again asserted that there was a change in the rules.

In the 2005 ColorSync thread, I was again accused of changing the rules because I should have made clear that "photograph" and "computer-generated gradient" are two different items and that I would not accept a gradient for testing. Also, it was alleged that I changed the rules because my use of the words "color photograph" did not make it sufficiently clear that grayscale images were excluded.

Andrew's recent image saw more of the same obfuscation. When I said that the behavior of exotic RGB definitions is irrelevant, Andrew very piously said what he usually does when caught cheating on such occasions:

*"I didn't expect this scene or any additional scenes I can capture with this sub-\$1000 camera to 'fit' your criteria since once again, that seems to be a moving target. So I've come to the conclusion that no matter what one does to try to show the advantage of high-bit editing, it will fall on at least two deaf ears."*

I've never accepted such files for testing. Andrew Rodney knows this, because he complained about this condition in 2000, in a thread that's archived on our site. He correctly pointed out, and I agreed, that ultra-wide RGBs are more likely to show a difference. I replied (remember, this is 2000):

*"To me, it's like asking how many angels can dance on the head of a pin. Nobody to speak of is using wide gamut RGB. There are a lot better uses of our time than to investigate the question of whether it needs 16 bits. I \*have\* looked at the issue in Adobe RGB and don't see that the extra bits are useful there. As I mentioned earlier I would be anxious to see images from anyone that might contradict this."*

Further, in the 2005 ColorSync thread, I specifically suggested that the ProPhoto space might sometimes show a difference between 16-bit and 8-bit editing if the edits were extreme enough. Seizing that suggestion, Andrew created his example--and then feigned shock that I wouldn't accept it, even though he had known for five years that I wouldn't.

This type of behavior is only what we have come to expect. As has already been pointed out, both Andrew and Bruce have tried to deny that they said the wild things they did five years ago. And, particularly, the intentional falsehoods on the Lindbloom site have been called to Andrew's attention again and again on this list and elsewhere. Yet he continues to pepper cyberspace with references to it. Every time he does so, he shames himself.

## **WHAT THE EXTRA BITS REALLY DO**

Understanding statistical concepts is not easy even for those with extensive training in the field. Casinos have lost hundreds of millions of dollars to mathematically astute players because the professors the casinos hired to advise them on probabilities failed to comprehend certain statistical interactions. The New York Times polled academics about a statistical interpretation puzzle called the Monty Hall Dilemma, and the majority of professors of mathematics gave the wrong answer. Both of these examples are absolutely child's play in comparison to trying to interpret what makes a picture look good.

Progress in our field has been hampered considerably by "experts" who are so terrorized by histograms that they don't understand that they feel they will sound more authoritative if they try to terrorize their readers with them as well.

The calibrationism of the 1990s, the fear of applying easy curves to images for fear of "irretrievable data loss", the phobia of LAB, the insistence on applying profiles to things that obviously can't be profiled, are all symptoms of the same disease. The confusion between gradients and digital photography is one of the best examples yet.

A computer-generated gradient is a perfect file. Each pixel gets its optimal value. Working in 16-bit gives extra precision, and it's unconditionally better for gradients than 8-bit is. It's possible that the two methods might give equivalent results. It's possible that the 16-bit might be better. But it's not possible that it would be worse. Also, it's easy to come up with a demonstration that shows damage by editing such files in 8-bit as opposed to 16-bit.

Now, contrast that to a digital capture. It is shot through a lens that is not perfectly clean; through air that contains particulates; it is captured by sensors whose performance varies with age and which may not be clean themselves. The data is demosaiced by an algorithm that we know nothing about. The vendors apply blurring to certain areas, and generally apply contrast-enhancing curves in certain others. Finally, the data is written using an unseen method to a format that may contain its own irregularities.

For all these reasons, the idea that even 128 levels per channel, let alone 256, are being captured with any degree of accuracy is very dubious. Yet if you open a digital file, up comes what looks like a nice, smooth histogram. That is enough for the 16-bit advocates to put their minds into neutral, prostrate themselves in front of it, and start salaaming. They assume that because the histogram looks like that of a gradient, the image will handle just like a gradient does. That's like saying that because champagne tastes good, motor oil must, or that because a helicopter can fly, it follows that a submarine can.

In real life, parts of what the camera captures are much more reliable than others. The better the shooting conditions, the more reliable the information. An underexposed image has less than 8 bits of accurate information anywhere. A shot in studio conditions has *more* than 8 bits of accurate information in the midrange of its green channel, less throughout its blue channel and in the shadows of each channel, and the rest is debatable.

CCD and CMOS devices, such as digital cameras, are notoriously poor at extracting shadow detail. Every manufacturer tries to fight noise by using some kind of blurring routine. Similarly, all digicams have difficulties with noise in blue areas, such as skies, and result to all kinds of demosaicing shenanigans to reduce it.

In these areas, the values that the camera spits out are approximations only. In the darkest eighth of any channel, an 8-bit file has 32 available tones. There is no digicam that I've ever seen that is even remotely close to capturing these 32 tones reliably. An 8-bit file allows for more precision than the camera has in shadow areas. In these shadows, the 8-bit file therefore already consists of somewhat random numbers. Making it a 16-bit file adds *totally* random numbers in these areas. The histogram-worshippers are fond of using the term "quantization error", but this merely shows their statistical naivete. In contrast to a gradient, where the 16-bit file is mathematically more reliable, the 8-bit file is mathematically purer than the 16-bit in the shadows of a digital photograph. Since, in shadows, the extra bits are random numbers, working with a 16-bit file simply adds soft noise in transition areas. Skies behave similarly.

[Hum... le totally random me paraît très douteux. Pas réaliste, peut-être, comme expliqué ci-dessus, mais pas n'importe quoi – CV]

My apologies for lapsing into techspeak. A reminder that this effect is so tiny as to be undetectable under real-world circumstances. However, if the file is stressed sufficiently (as Andrew was doing with his exotic RGB definition and his sharpening sabotage) then we may be able to perceive it--and what we will perceive is that editing in 16-bit amounts to applying a blur to these areas- -a highly sophisticated blur that is hard to emulate by other means.

As far as I know, all of the claims about the images in which 16-bit supposedly is better involve either skies or shadows. Makes sense--we often blur these areas separately no matter how many bits are involved. The camera's algorithm blurs them already, but sometimes it isn't enough.

Unfortunately, if you do enough to the 16-bit file that its inherent blurring has an impact in shadows and in skies, it's likely that it also may have an impact in areas where you *don't* want blurring. That accounts for the preference one viewer had for the 8-bit version of Andrew's file. In the shadow areas it was worse, but in the foreground areas that were full of detail, it was better.

An even more striking example showed up in the last two months, where another 16-bit advocate posted a demonstration at [http://www.visual-vacations.com/Photography/16 vs 8.htm](http://www.visual-vacations.com/Photography/16_vs_8.htm)

The image is one of a barn constructed of dark wood, taken in normal daylight. The complaint is identical to Andrew's, namely that correcting in 8-bit created undue noise in the shadows. The procedure in this image is similar to Andrew's as well, but there are some variations--especially in the result.

- (1) Both are definitely real-world images. This demonstration is in sRGB, which is fine. Andrew's is in ProPhoto, which disqualifies it right off the bat.
- (2) This image is intentionally sabotaged by acquiring it in such a way that it enters Photoshop grossly dark, and is therefore immediately disqualified, because in the real world, we do not sabotage images on acquisition. Andrew's image, by contrast, was acquired fairly.
- (3) Both images now take Levels changes and, in Andrew's case, Hue/ Saturation. Fine.
- (4) Now, the attempt to slip in the sabotage. Andrew sharpens using a zero Threshold, which is clearly intended to bring out noise and thus disqualifies it as a real-world move, since in the real world one could achieve the same sharpening affect with a Threshold of 2 or even 1. The other demonstration does this not just one better, but five better: it tortures the image with four consecutive zero-threshold sharpens, plus two applications of Shadow/ Highlight, which is a form of sharpening. Again, not real-world: in the real world, when we have two alternatives, we choose the one that looks better, not worse. The purpose of sharpening is to make the picture look more natural, not more noisy.
- (5) And the startling bottom line: while both exercises show more undesirable noise in the shadows in the 8-bit versions, images don't consist entirely of shadows. They need to be evaluated as a whole. I'm familiar with how juries vote when given unidentified samples to choose from. We have one report that with Andrew's image the 8-bit version was chosen as better. I don't think that a jury would agree--I suspect the verdict would be a tie. With the other, however, I have no doubt. The shadows are worse, for sure, but a jury would pick the 8-bit version as better overall, because the same blurring effect in 16-bit that helped the shadows also blurred the main interest object of the image, the wood of the barn.

If editing in 16-bit were truly "better", there wouldn't be examples where editing in 8-bit appears to give superior results--it couldn't, any more than editing an 8-bit gradient can possibly produce a superior result to doing it in 16-bit. Also, it is very telling that the examples being used always

are either skies or shadows, and never the third major category of image that we frequently have to blur: fleshtones. I would suggest that the reason is that camera captures of fleshtones are very much more reliable than either of skies or of shadows. There is therefore less need to blur due to inadequacies of the original capture. Even though the extra bit depth in fleshtones is probably real information and not noise, it doesn't serve a useful purpose.

## OTHER VIEWS

I would like to close by quoting at some length two other experts who have conducted their own tests. In the 2005 ColorSync thread, Jeff Schewe emerged after I had left, and, unbothered by the overwhelming evidence that there is no quality difference at all, reiterated the same old silliness: "I would argue that it [is] critical that ALL MAJOR tone and color moves be done in 16 bit."

Jim Rich replied,

*"As working in 16 bits to avoid all of these Urban Legend pitfalls such as: The color being day and night different from 8 and 16 bit images. That 8 bit files are fragile in terms of color reproduction. Or that you will get artifacts like banding in gradients after a lot of image editing. That 10% percent of images require 16 bits so they don't break. Or that you need to work in 16 bit because of device responses. Let me say again on those points, I am more than skeptical that you require 16 bits. My experiences with RGB photos, CMYK print and Inkjet printing do not indicate that one should jump to those conclusion. And we know that mileage will vary. And until I see a test or some other type of hard evidence that all of these problems really exist and are as wide spread, as reported I can't buy into the notion that there is an advantage to going to a full 16 bit workflow for a few renegade images. It would be interesting if some one would please show me a suite of images where the benefits of 16 bit images jumps off the sheet and it is clear what is an 8 bits and what is 16 bit file. Then I can really buy into the 16 bit way of life. "*

It's hard to know what more could be asked. Jim admits that it is impossible to prove that there will *never* be a case where 16-bit is beneficial, any more than one can prove that it would never be beneficial for a righthanded person to work with the mouse on the left-hand as opposed to the right-hand side. As indicated above, several 16-bit advocates have said explicitly that demonstrations don't matter: it is so obvious that 16-bit is the better way that it requires no proof.

Tim Grey, one of the rising stars in the Photoshop field, wrote this in his September newsletter:

*"In a general sense, I do indeed agree with Dan. The way I explain this issue is that 16-bit editing provides more 'headroom' for editing, ensuring you won't create posterization in the final result. However, I've also tried to make it clear that the vast majority of the time, you will never see any benefit at all from optimizing your images in 16-bit. The simple fact is, even if you strip out a significant number of tonal values in your image, you'll still have an adequate range to produce what appears, to our eyes, to be perfectly smooth gradations. I often do a demonstration in my workshops as I posterize an image and ask students to tell me when they see posterization. In general, I get down to about 32 levels per channel before anything is visible, when there are 256 available in 8-bit per channel images. So why do you need 16-bit? The short answer is, if your computer resources can handle it, you might as well keep your images in 16-bit to preserve as much detail as possible, especially considering that output devices continue to improve, and at some point we may have output*



*that tests the limits of our 8-bit files, where you'd actually see a difference. The only time 16-bit would make a difference, for all practical purposes, is if you need to make extreme adjustments to the image. If that's the case, you probably would throw the image away, right? So 16-bit isn't a significant advantage to most of us. Still something I recommend as a 'just in case', but not likely to provide any practical benefit."*

This is a sensible summary. Personally, I doubt that there's a realistic possibility of benefit, but certainly you never know, and if you care to speculate on it and have the disk space and computing time to spare, nobody is criticizing. I believe it's more likely that some weirdness in an output device will create a benefit than anything at the high-end. Naturally, I also think that the most likely image to show an advantage would be one consisting of a sky and little else, or an image with almost no detail outside of deep shadows.

## **LESSONS FOR THE FUTURE**

From the perspective of people who purport to be Photoshop authorities there is a lesson to be learned about giving non-experts a hard time in public. You never know when it's going to turn out that your views are mistaken, and then you look ridiculous.

Second, admitting that one has been wrong is not a disgrace. Rather, I think it gives one more credibility. Image processing is an infinitely complicated field.

In every new edition of Professional Photoshop I've pointed out areas where I was previously incorrect. In the LAB book I talk about how I misunderstood some of the sharpening issues. In at least two sections I pointed out images that I had corrected badly.

Third, we have to grant that the difference in results between 8-bit and 16-bit editing is not trivial to comprehend, even by people with a lot of color knowledge, even after a lot of testing. On the other hand, anybody who claims that converting to LAB causes "catastrophic damage", that working on several adjustment layers creates better data than applying the same corrections consecutively, or that there is a "night and day difference, totally obvious to anyone who looks" between 8-bit and 16-bit editing, is either too lazy or too incompetent, or both, to do the ten minutes of testing that it would require to cast serious doubts on these assertions.

Fourth, some sense of priorities has to be invoked. Some of the people who have been most strongly in favor of 16-bit editing don't know how to set highlights and shadows. Some actually edit not just in Levels but using the master setting rather than channel-by-channel. Under these circumstances the gain (if any) from 16-bit editing is about #4,807 on the list of things that might help the image look better. Remember: even if some exceptional image does show up that indicates an advantage for 16-bit editing, in all probability the edge will be so minor that it can easily be compensated for. But to this point, we haven't even gotten that far.

Users aren't blameless either. The entire imaging field is pervaded by purported experts peddling solutions, myself included. Users tend to be properly skeptical of claims made by unknown vendors, but a surprising number of people are buffaloes by histograms and claims of mathematical precision. Before buying into anybody's pet theories, readers should insist upon

images, not a bunch of pseudoscientific gobbledygook. If the speaker can't phrase the concept in a manner you can understand, perhaps he can't understand it either.

Users would be well advised to steer clear of anyone trying to justify conversion or color correction theories with gradients, using terms like "quantization error", or trying to convince us that a good-looking histogram is more important than a good-looking image. Above all, when people come up with new nostrums, ask to see images, not theories.

Finally, it should be remembered (as always) that color knowledge is always evolving and that today's conventional wisdom is likely to be considered wrong in ten years. I hope that the history of the correction method that started out as *extremely critical*, a *night and day difference*, *the difference between a professional and a recreational user*, and became *possibly a non-issue* will be an instructive one.

## Part IV

This is an appendix to my three posts on the 8-bit vs.16-bit editing issue. Much of my post is critical of those who insist that 16-bit editing is of paramount importance yet decline to show any real-world images where there is any indication that editing in 16-bit is better. I am posting here extensive excerpts of what they say in their own defense as to why they do not.

Before turning it over to them, I have only one remark. These individuals have argued that editing in 16-bit is *extremely critical*, that it is *the difference between professional and recreational users of Photoshop*, that doing so results in a *night and day difference* that is *totally obvious to anyone who looks*.

If anything even remotely close to that were true, a demonstration could be made of it almost instantaneously. For example, if I had to argue for why gradients should be created and edited in 16-bit and not 8-bit, I could create a convincing example showing why in less than ten minutes. Both of the individuals quoted here spend a great deal of time in on-line groups. They have each, conservatively, spent tens of hours, possibly more than a hundred apiece, explaining why they are too busy to take these ten minutes.

Dan Margulis

Note: Jeff Schewe, one of the posters here, often uses ellipses (. . .) in his messages. Where these appear, they are in Jeff's original and do not represent deletions. Some extraneous paragraphs have been deleted from the beginnings and ends of messages, but there is no editing of the text.

Jeff Schewe - 10:32pm Aug 5, 2001 Pacific

*I have no interest in "Educating Dan". That's his job. Dan is right about a lot and wrong about a lot. It's very easy to see that substantial color & tone editing will eventually result in data loss and banding. A lot of people have banding problems, very few people know when and where that banding occurs, but it's due to the fact that editing 8 bit files causes the banding.*

*If you start with an 8 bit file and do tone and color adjustments, you lose levels. . . maybe only a few. But, combined with data loss due to rounding errors running filters, rounding errors due to layer blending, errors due to re- brushing all accumulate to eventually produce enough loss of data from the original that eventually you get banding.*

*But. . . I have no interest in debating Dan's position on the value of 16 bit editing. . . I prove him wrong every day. If he wants to pay me to come teach him the value of 16 bit editing, I'll be happy to. . . but I'm certainly not going to do his job for him for free <BG>.*

*He asked me to prove it to him. . . I declined. If he wants to take one of my classes, he's welcome to. . . I'll give him a discount. . .*

User 1 - 11:53am Aug 9, 2001 Pacific

*Jeff, I will address you here, but my point really goes out to all. Please don't take it personally. Regarding Margulis' challenge Jeff writes: "He asked me to prove it to him. . . I declined. If he wants to take one of my classes, he's welcome to. . . I'll give him a discount..."*

*While I appreciate your humor here, I am mystified as to why you (and others who feel as confident as you in the matter) decline his challenge... Taking Dan's challenge would be to our benefit, not Dan's*

*Here is a sampling of Dan's challenge to you: "... I have for several years asked here and elsewhere for those who advocate these methods if they might not be able to provide me, say, two or three sample original high-bit images, with a record of what moves were applied to them, so that I could verify that there is a quality gain, however slight, in applying them to a 16-bit image as opposed to an 8-bit one. Since I have been making this request, what I have received is a large number of histograms purporting to prove that 16-bit is better, a large number of assurances that '16-bit has worked better for me', and a large number of excuses for why the images in which it has worked better are either unavailable or under NDA. As time has gone on I have grown to suspect that perhaps the reason no one can supply such images is that there are no such images to supply. Can you help me out? If you or anyone else can supply such example images and they really demonstrate the merit of working in 16-bit, I'll be glad to let this list know and if the differences are significant I'll print them in my column at a size large enough for people to see. If you or anyone else has such images, just let me know and I'll give you shipping instructions."*

*To my mind Dan is being very fair in the matter, while those who decline his challenge prove his accusations right, even if his assumptions about bit depth may be wrong. He is*

*certainly in the minority opinion on the subject, yet he is the only one to my knowledge who is willing to back up his assertions with examples. Why not back up your declarations to the degree that Dan is willing to back up his?*

Jeff Schewe - 08:16pm Aug 9, 2001 Pacific

*I know Dan pretty well. . .I have ZERO interest in being a subject of an upcoming article (I feel one coming from Dan) where he can take what Bruce or I may say about 16 bit and twist it around. Suffice it to say that remaining under Dan's radar is far more comfortable <BG>*

*In the old days (before learning the value of editing in 16 bit) I suffered from slight to severe banding on transparency and CMYK output. since switching to the 16 bit approach, I no longer get banding. . .that's all the proof I need. I have no need to "prove it to Dan". Sorry. . .I say what I say. . .I'm willing to spend time teaching how to work in 16 bit (and do things the engineers never dreamed of), but I have zero interest in proving anything to ol' Danny boy. . .*

*I doubt Dan has ever seriously manipulated an image or done a 6 element assembly. I seriously doubt that Dan is after the most supreme high end quality. . .even if it's only marginally better. . .but working in 16 bit is seriously a better habit leading to better quality in the end. . .which is all I care about.*

*P.S. ask Dan about copyrights some time. . .he's got his head firmly lodged up an orifice about that as well <BG>.*

User 1 - 09:53pm Aug 9, 2001 Pacific

*Jeff, Well, I hear ya, but..... I was just hoping that someone would prove the point in the material world, rather than theoretically, or anecdotally. Somehow this has become about Dan Margulis the man, rather than the point he makes. It's ironic that although it's him against the world on this, he's the only one (seemingly) willing to post evidence to support his claims. Shouldn't the benefits of a 16-bit workflow be demonstrated anyway, regardless of the fact that Dan has issued a challenge? Why, with all that is published about PS in print and on the web, is such a presentation not already extant? That's just weird.*

User 2 - 08:00am Aug 10, 2001 Pacific (#37 of 52) [Another 16-bit advocate] wrote:

*"What do you want someone to do? Prepare a costly print run or film recorder output using both good image preparation and bad image preparation so that you can be satisfied that we know what we're talking about?"*

*Certainly not, that would be unreasonable. That's why I asked if the difference could be seen on a monitor, and you said at 100% magnification or higher it could.*

*Even so, I'm not asking that you supply images for monitor viewing. Your time is valuable, and you have been very generous with it on this forum.*

*on the other hand, it seems that someone who advocates a 16 bit work flow could supply a set of files for comparison. Lots and lots and lots of time has been spent discussing this issue, here and elsewhere, which is still unresolved in the minds of many people, and it could so easily be put to bed by just showing us the comparisons. Otherwise, as Rich said, it becomes tiring.*

Jeff Schewe - 09:40am Aug 10, 2001 Pacific

*Your points are taken. . .but proving anything is not my job. When I do notes for classes or lectures, it takes on average about 8-12 hours to prepare them. I do have notes on editing in 16 bit on my web site (I'm going to be changing the url this weekend for an upcoming class but they will be in the site map), but those are just techniques for working in 16 bit. To go through and offer scientific "proof" is something that would require even more time- which I don't have.*

Jeff Schewe - 05:30pm Aug 12, 2001 Pacific

*All this debate is pretty typical of good old Dan. You notice he recently said that he has not taken the position that editing 16 bit is NOT better. . .only that he's never had anybody PROVE it to him.*

*I'm almost getting pissed off enough by Dan's "positioning" that I might decide to "prove it". But I don't have a great deal of time in the next week or so, so it would have to wait a bit.*

*Date: Wed, 15 May 2002 22:37:56 -0500 From: Jeff Schewe Subject: Re: 8- and 16-bit correction I watched, with amusement, when Dan challenged anybody to come up with a 16 bit image that could prove the benefits of editing in 16 bit over 8 bit. I now understand there's a bounty out there of \$100 if somebody can prove that edits in 16 bit vs edits in 8 bit is superior. . .*

*That's a waste of time (and believe me, \$100 is no incentive to me).*

*Fact is there is no image that can prove that one to several edits in 16 bit vs 8 bits is better. I've never advocated editing in 16 bit merely as a method of improving a few tone/color corrections. That's silly. The edits done in the beginning of a tone/color correction does not cause banding. It does indeed "spend bits" and I advocate spending your bits wisely. Where the \_REAL\_ difference between 16 & 8 bit editing comes is well down the road. Well after your original edits.*

*Photoshop is pure math. . .everything is numbers. Everything done in Photoshop is the result of an algorithm. And believe me, Photoshop's precision is not infinite. Where the benefits of original 16 bit editing shows is down the road after doing corrections and applying a filter or two (or dozen). Add a dozen layers with various opacities and blending modes and maybe a layer effect or 2. Do a gradated adjustment layer. Do any series of extended retouching or manipulations that many image artists do every day. Then you'll find out that at some point in the process, you've rounded enough data and spent enough bits that the gradation between point "A" and "B" no longer has enough bits to produce a*

*smooth gradation of tone or color. Guess what, you've got banding. And, guess what else, you've just proved that \_STARTING\_ with your initial tone/color edits in 16 bits and conserving your data bits to spend later in the editing process allows you to avoid the dreaded banding.*

*If you scan a chrome and do a slight to moderate curve correction and transform from RGB > CMYK, should you scan in 16 bits? Nope. If you do slight to moderate to even substantial tone/color edits and then plan on assembling 1/2 dozen composited images with filters, layer blending and effects and maybe 20 hours in image manipulations, will you benefit a \_LOT\_ from doing your original edits in 16 bits? You bet your ass you will.*

*I started scanning in 16 bits because I ran into constant problems of ending up spending hours working on an image only to find that at some point, a tone gradation in an image banded. Once banded, there's nothing you can do to recover the lost spent data.*

*My point is that if you need maximum flexibility and edit ability and you don't want to worry about banding, start your creative retouching in a "perfect 8 bits/channel". That only comes after doing initial tone/color corrections in 16 bit.*

*Sure, you can use the scanner software to do tone/color corrections in the scanner's high bit depth and thus benefit from 10, 12, 14 or 16 bits of data. The big problem I have with that workflow is this. . .there ain't a scanner on earth who's software allows you to do "local" corrections of tone/color. Scanners don't come with the ability to put a lasso around an area to adjust just that area. The other weak point of scanner (or camera software for that matter) is that a scanner preview just purely isn't as accurate as Photoshop to show exactly what the pixels look like. Scanners give "previews" but you don't see the full resolution till \_AFTER\_ you've applied the tone/color corrections during the scan. At that point if you touch it again you won't have a full 8 bit file. . .you're spending the bits on a wasted edit. I also think, and perhaps I'm biased, that Photoshop is the best "pixel viewing" application on the planet. I know of no other app that is as accurate in showing on screen, exactly how a set of pixels will look when you output. . .either photo or halftone reproduction. So, if I want the most accurate on screen representation of just exactly how those pixels will look reproduced, I'm just not interested in using a scanner software or camera capture software's interpretation of those pixels.*

*Nope. . .Dan and the rest of you are welcome to continue scanning in 8 bits and doing whatever you want to do to your images. . .but if you want absolute total control over tone and color without the risk of breaking the image somewhere down the road. . .you better learn to edit in 16 bits.*

*Yes, the tools are more limited and yes the files are 2x the size. . .so? Ram is cheap and so are hard drives these days. I've learned to edit in 16 bit to the point where even the Photoshop engineers couldn't believe how far one can go if you're determined. You can paint (using history), you can copy/paste (using clone between 2 16 bit documents), you can use adjustment layers (in an 8 bit duplicate and save out as a setting), you can use color range in 8 bit and transfer the 8 bit selection into 16 bits for application. You can clone and*

*heal and run enough filters to do just about anything you need to do to start off your imaging in the "perfect 8 bits".*

*And yes, I'll stand by the line "recreational" if you squander and waste your data bits just getting an image tone/color corrected in 8 bit. . .cause if you do that, you're working with considerably less than 8 bits/channel and deserve the banding you are likely to incur.*

*Dan and others who claim 16 bit editing isn't better than 8 bit editing for routine scanning and corrections are correct. But, I'm a photographer and image manipulator. I choose to spend my data bits wisely because because what I do to images isn't routine. I manipulate the heck out of images. I choose to do all initial tone/color correction in 16 bit to avoid banding down the road. And, personally I feel no compulsion to prove anything to anybody except my clients that pay me a lot of money.*

*Regards, Jeff Schewe 16 bit advocate and proud of it. . .*

Date: Fri, 15 Apr 2005 14:36:12 -0700 From: bruce fraser

*The major problem with the methodology (leaving aside the minor ones) is that by making identical edits to the 8-bit and the 16-bit, you're throwing out any benefit the extra bits may bring. They aren't useful unless you DO SOMETHING with them!*

Date: Sun, 17 Apr 2005 15:00:55 -0700 From: bruce fraser

Subject: Re: 16 bits = 15 bits in Photoshop?

*At 12:39 PM -0400 4/17/05, Dan Margulis wrote:*

*>So, I ask if the following is a fair summary of your position:*

- >1) Bruce states that the argument has never been that identical edits applied*
- >to 8-bit and 16-bit files would produce better results in the 16-bit version,*
- >but he argues that it is possible that they might.*
- >>2) Bruce has not offered up any images that would demonstrate such a*
- >superiority for 16-bit correction (as opposed to identical edits*
- >applied to 8-bit), >but he suggests that such images might exist.*
- >>3) Bruce's comments on "night and day difference" and "totally obvious to*
- >anyone who looks" are based on his experience and perceptions; however, he has*
- >never personally tested a series of corrections done to a 16-bit >file on a live*
- >image versus identical corrections done to an 8-bit one.*

*No, that's a when-did-you-stop-beating-your-wife characterization.*

*My position is very straightforward.*

*I proved to my own satisfaction many (>10) years ago that many of the problems I encountered with 8-bit files-posterization, striped skies, exaggerated saturation accompanying contrast moves, and unwanted hue shifts-largely disappeared when I edited (and converted to output space, which is a big edit) in 16-bit instead.*

*I seem to be far from alone in having noticed this phenomenon.*

*I quite sensibly decline to do all my work twice with the goal of making half of it fail, and with the exception of beta-testing procedures that need examples for bug reports, I don't make a habit of saving the failures.*

*If someone wants to pay me my day rate to do so, I'm quite certain that I can come up with real-world examples, but I decline to donate my time to a foolish quest with whose premiss I'm in disagreement.*

*Anyone who sees no benefit to working in 16-bit space simply shouldn't bother doing so. But they shouldn't come crying to me when their images fall apart on output.*

*My personal opinion is that this is a manufactured controversy-I decline to speculate on the motivation of those who have manufactured it-and I'm utterly disinclined to waste my time arguing the point when I have better things to do with it.*

Date: Fri, 22 Apr 2005 01:29:17 -0500 From: Jeff Schewe  
Subject: Re: 16 bits = 15 bits in Photoshop? To: <colorsync-users@...>

*Jim Rich said: > It makes sense to capture everything as high bit images. Everyone seems to > agree on this.*  
*> Save the high bit parent file in your archive.*  
*> Create derivative 8 bit files from the parent file for production.*  
*> Use Adjustment layers.*  
*> If the 8 bit file breaks ( as they can in rare cases), then go back to > the parent 16 bit file and use the previous Adjustment Layers.*

*I agree with the capture in high bit.*

*But I would argue that it critical than ALL MAJOR tone and color moves be done in 16 bit. Ideally with Adjustment Layers for the simple reason that setting black & white points (unless you do it accurately in say Camera Raw) are the tip of the spear so to speak. Major gamma adjustments are second, such as when you stretch one area and compress another area of the image's histogram.*

*I would also argue that depending on the color space you may be in while in 16 bit, it would be a good idea, if at all possible, to do any major color transforms while in 16 bit.*

Bruce Fraser - 11:41pm Sep 16, 05 PST

*If you want to work in 8 bit/channel mode, go ahead. But don't come crying to me if your file breaks. That's really all I have to say on the subject. OK. A little more. Dan's "tests" are based on applying exactly the same traditional levels- and-curves-based edits to 8-bit and 16-bit files, then looking for differences. Those will likely be fairly hard to find. For the*



*type of work Dan does, 8 bits/ channel is undoubtedly adequate, otherwise, being a rational person, he wouldn't do it. Others may have different needs.*

Bruce Fraser - 1:07pm Sep 19, 05 PST

*I'd also suggest that you need to weigh the consequences of working in 8-bit and finding you need 16 versus working in 16-bit and finding you only need 8. My lack of clairvoyance is one of the factors that leads me to work in 16-bit.... I've demonstrated many times things that work better in 16-bit than in 8 bit, but Dan has rejected these because they don't fit his narrow criterion of doing exactly the same things to a 16-bit and an 8-bit file, then comparing the results.*

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## Addendum : contribution de Jim Rich

Parution originale dans

[http://www.ledet.com/margulis/ACT\\_postings/ColorCorrection/ACT-more-16bit.htm](http://www.ledet.com/margulis/ACT_postings/ColorCorrection/ACT-more-16bit.htm)

Date: Tue, 07 Jan 2003 09:05:55 -0500

From: Jim Rich

Subject: More on the high bit vs 8-bit argument

Dan Margulis some months ago made a challenge to the 16-bit advocates to either put up or shut up. So far, I have not seen anyone show hard evidence to prove or disprove Dan's argument. So far no one that I have met has. Dan's argument was so good, I took the time to create a test to either nullify or validate some of his tests.

The high bit depth advocates make a good case in theory. The theory is that there are more bits in each pixel in a 16-bit image. So when you apply image processing in a program such as Photoshop, you will have less quantization errors and therefore less potential banding and overall image degradation issues. But in practice when you ask them to show you hard evidence, that is, to compare 16-bit prints to 8-bit prints with the same number of edits, they have some rational arguments such as reviewing histograms, or point out that an 8-bit workflow will ruin your images because there is not enough data so your images will be ruined or the rational discussion often stops and sometimes becomes a battle of, 3my technique is better than yours because I say so.2

One of the key end-user benefits of using 8-bit images over 16-bit images is that in the 8-bit modes, Photoshop has more tools available and therefore has more capabilities for adjusting and manipulating images. Other benefits are smaller file sizes. Using 8-bit images makes the workflow more efficient.

## **The Test**

Last month (Dec 2002) at a color management conference, I setup and ran a test comparing 8-bit and 16-bit RGB images. For this test I printed 8-bit and 16-bit images via Photoshop (with profiles) to my Epson 5500 printer. Photoshop was set up to simulate an RGB workflow. Nothing was done purposely to bias the test. Images were scanned and brought into the Adobe 1998 working space. Some images in the test had 30+ edits as well as went from RGB to LAB and back a few times.

This was my third shot at creating a test and I am sure this is not the last one I will do since I only focused on RGB and not CMYK workflows.

For this test, I laid out the 28 prints on a table and let a group of imaging experts (pre-press types and photographers) inspect and review them. The test was not for color accuracy between prints. I gave any willing participant a form with yes and no response categories for yes, it is 8-bit or 16-bit or no, it is not.

The initial feedback from a group of experts who did not choose to fill out the form but who took a few minutes to compare the images was that they could not precisely see any visual differences between the 8-bit or 16-bit images and that any response they would have would be a guess. This result was verified again with approximately 20 test forms that were filled out. The overall outcome showed all participants were guessing (40% to 50% of the time) at which images were 8-bit or 16-bits.

## **Histograms Can Guide You But**

The images I used were at risk to posterize due to the combination of their image content and the extraordinary image processing that was applied. Except for one image that had banding in the original, all images fared well and they did not degrade as one might expect.

In theory, one might have a bad looking histogram (with lots of gaps), making one believe that the image will posterize. In this test, all of the 8-bit histograms looked bad. However, the number of visible gaps in these histograms was not the defining factor, it was how the final prints looked. Any other problems, such as banding or image degradation related to too many image-processing edits, were indistinguishable.

## **Are more than 8-bits necessary?**

The test I have described covers a majority of images used in most RGB workflow situations. But, there are some exceptions. So as you look at and consider the implications of this information, take care. Some situations require using 16-bit images in Photoshop.

1. One reason to work with 16-bit images in Photoshop is if your original image (film) has a harsh break or banding in the way the image was originally photographed and/or in the way the film processed. Once you scan that problematic image into your system, using 16 bits will allow you to process the file without much degradation to the image area with the harsh break. If you apply the same image processing to an 8-bit image, the file will degrade and fall apart. One solution is to only scan those types of images as 16-bit. Then work in the 16-bit mode as long as possible. Since banding problems show up in a small percent (2 percent or less) of all images that means 98% of all images should be scanned into an 8-bit workflow.
2. What I have commented on is related to working in Photoshop. It does not mean you should only use 8-bits for image capture, that is, for scanning and digital cameras. Digital cameras and scanners often need more than 8-bits per pixel to capture a good range of tones so you can get good shadow detail and color saturation. An input device that can capture over 8-bits per pixel is a positive attribute to an imaging system. After the input device does the capture, say in 16-bits, and if the image does not have any banding created in the original photograph, then switch to 8-bits and begin your working session in Photoshop.
3. In the early days of desktop scanning, and digital cameras the development of sensors, and optical technology and poor implementation of scanning and digital camera technology caused lots of banding problems. One of the technical reasons for banding was poorly written scanner drivers. The problem typically was created by inadequate or incorrect math when the driver was developed and written. At that time (actually just a five or six years ago), this problem made some experts recommend working in 16-bits. At that time, it was probably the correct thing to do. In the last few years, scanning and digital camera technology has matured and become much improved. Recent tests, including mine, validates that there are very few reasons to create a high bit depth workflow as least for RGB workflow.

If you are skeptical about working in 8-bits then consider this strategy. Use the scanner or digital camera to capture the best 16-bit data. Make a copy and work on that. Use the original as a backup.

From an end-users perspective, the reality is, if you have a scanner that introduces banding with either 8-bit or 16-bit images, fix the problem either by acquiring a better scanner driver or by getting a new scanner.

In the initial stages of these tests, I actually had a 16-bit image with banding from an older 16-bit scanner. This actually fooled me until I rescanned the image on our newer and improved 8-bit and 16-bit scanner. The problem went away.

In another part of this testing, I took a group of these test images to a photo finisher and output some of them to a Lambda print device and a to a LVT Transparency (Light Value Technology) device. Again, on photo quality prints and transparencies, the 8-bit and 16-bit results were indistinguishable.

**The Bottom Line.**

The conclusions of this post are based on hard evidence and years of practical experience. If you are skeptical, my advice is to consider this: If you have a good input device with well-integrated technology, it should offer high bit depth capabilities. Do some test scans or digital capture in both 8-bit and 16-bit modes. If the 8-bit mode has any problems you don't like, then use 16-bits as a capture option. Then in Photoshop convert to 8-bits and start your working session. The only exception would be images that have banding built into them then you would want to work in 16-bits as long as possible.

Jim Rich

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Your tests and conclusions basically agree with mine. I originally set out to try and prove, not disprove, a 16 bit advantage. I'm proud to say some of my testing is represented in Dan's excellent new book, including some 8 bit and 16 bit image details on the CD. I've personally seen examples of, and have heard of real world tests like yours, which fail to prove a 16 bit workflow advantage.

Unfortunately, the 16 bit proponents are treating it as an article of faith and I've never seen any purported examples of a file that benefited from being worked on in 16 bits so I could agree or disagree with their methods. Yet practically every month I see the 16 bit advantage quoted as a matter of irrefutable fact. As a former science major I find this "religion based" attitude infuriating. I too would love to find a magic way to improve my images, I just see no evidence that this is it.

Ric Cohn

<http://www.riccohn.com>