High Resolution Sensors

If you own or are thinking about a camera with a high resolution sensor, it's not too late to consider its benefits. There are valid reasons for owning such a camera but their megapixel resolution may not be one of them.

Why would anyone want to capture something that nobody else can possibly see? Why invest thousands of dollars to make that happen? It should not be hard to understand why it might be a waste of money.

Viewing the Digital Image

An ordinary 2k monitor displays 1920 pixels wide and 1080 high. For a monitor that is 24 inches wide that is a resolution of 80 pixels per inch. A 4k monitor can fit twice as many pixels each way at a resolution of 160 pixels per inch (ppi). Different monitor sizes will display the same number of pixels over different physical dimensions so the ppi values will be different.

To calculate the number of pixels displayed on your screen, multiply the height and width in inches by the ppi for each dimension. For a 2k monitor, (24x80) x (13.5x80) = about 2 million pixels (2MP). On a 4k monitor it is about 8MP. A megapixel is actually 1,024,000 pixels.

When we look at an image on a monitor that is 24 inches wide, we can comfortably see the entire screen from about 24 inches away. If you get any closer your eyes will need to scan the image like you would when reading a book.

On a 2k screen you can just begin to see the individual pixels from a distance about equal to the width of the screen. But on a 4k screen you need to move in to half the screen width and you will not be able to see the entire image.

When viewing an image at 100%, you will see only a small portion of the image, one image pixel for each monitor pixel. Above 100% the image will become pixelated because it will take two or more monitor pixels in each direction to display a single image pixel.

The only person who is likely to view a digital image at 100% is the original photographer, you.

The conventional wisdom that a high megapixel (MP) sensor can produce sharper images is something that is easy for the photographer to confirm when they import an image to their computer and blow it up to 100%. But if the image is more than 2MP it will not fit on a 2k screen and more than 8MP will not fit on a 4k screen.

It may not be in your best interest to distribute an image larger than 8MP for public viewing.

Viewing the Printed Image

The ability to see sharpness in a print is a function of visual acuity. It is limited by our own eyesight, not by the lens or sensor on the camera. The following discussion assumes that the viewer has normal vision.

When you print an image you will no longer see the individual pixels. They get converted into ink dots that are much smaller than pixels. Pixilation is a problem that is a characteristic of digital displays. But if you don't have enough pixels start with you might have trouble producing a satisfactory print. As we have already seen with our look at monitor resolution, anything more than 2MP should be enough to make a good print to be viewed from a normal distance, about equal to the width of the print, 8MP would be better.

But do we need to go above 8MP? Camera manufacturers would like us to think so because they would like you to spend more money. So would our peers because they have already spent more money and they would like to believe that they were right to do it. Before succumbing to advertising or peer pressure you owe it to yourself to give this some thought.

There are many reasons to get a newer camera.

- It may be smaller and lighter.
- The ergonomics might be better.
- It might be easier to use than your current camera.
- You might have a wider selection of lenses.
- Your ISO range might be wider.
- You might have more dynamic range.
- Noise control might be more effective at higher ISO.
- Autofocus might be faster.
- The camera might be more reliable.
- You might get a better shutter.
- You might be able to capture more images in a short burst.

Camera resolution and lens sharpness should not be your top consideration.

Does 300 ppi ring a bell? It's the highest resolution that anyone with normal vision can appreciate from a distance of about 12 inches. It's used as the default basis for DOF calculations because that's the threshold of our ability to judge sharpness.

An 8x12 inch print viewed from 12 inches (the normal viewing distance) can contain (8x300)x(12x300) = 8.64MP, as sharp as the eye can see. When viewed from a greater distance the required ppi goes down.

A 16x24 in print viewed from 24 inches only needs a resolution of 150ppi to look equally sharp. The resolution (16x1500)x(24x150) = 8.64MP is the same. It is only slightly more than you can see on an 8k monitor. An image enlarged to 8x12 meters will look the same from 12 meters and need only 8.64MP.

When the Nikon D700 came along in 2008, it was clear that 12MP might just be ideal, just a little more resolution than necessary.

Nikon introduced the D800 with 36MP in 2012. They knew that photographers are not normal. They are easily persuaded to spend lots of money for something they might not really need. At the same time they introduced the D7000 with a crop sensor and 16MP. The pixel density was the same as the D800. The D7000 had a little more resolution than the D700 but the D7000 had an APSC sensor and the D700 was full frame.

Competitors joined the MP race, not to make better prints, but to make more money.

There is still an incentive for the manufacturers to offer more resolution because it sells to photographers who don't do the math. They obsess over whether they can see a difference between two lenses at 45 or 61MP when they view them at 100% resolution on their computer. So they buy more expensive lenses but they are the only ones who will ever see the difference. A normal viewer won't see is, even if we try to explain it to them.

If 12MP is good enough, 24MP may be twice as good. It even covers up the gap between normal and 20/20 vision. It will make up for the unavoidable loss of sharpness caused by the demosaicing process (the green pixels are only 12MP, red 6MP and blue 6MP). Currently, 24MP is the most popular resolution for modern cameras.

There is a logical reason to feel that we don't need more than 24MP. But there is a useful reason to get a camera with a resolution higher than 24MP, to test your lenses.

A used Z7 is an economical way to test lenses that you want to use on a 24MP camera. You can get rid several obvious losers and hang on to your best older manual and autofocus lenses.

Comparing the Z7 as an alternative to a Sony A7 III (24MP) we won't see any difference between images exported for printing between the Z7 and the A7 III at 21x14 inches viewed from 21 inches at 170 ppi, (21x170)x(14x170)=8.5MP. That's still the minimum, 24MP adds a cushion.

If 24MP is almost 3x as much resolution as we actually need for a print, then any sensor with a higher resolution will not provide any visible improvement in the print itself.

For black and white, the measurements from the 45.7MP Z7 are no better at 100% on a digital display than a 24MP A7 II from which the Bayer array has been removed. That test confirmed that the demosaicing process degrades the sharpness by about 50%. Instead of the 22.85MP of green pixels, the A7II has 24MP of gray pixels.

The Depth of Field Factor

Depth of Field (DOF) is a factor that is seldom mentioned when comparing sensor and lens resolution.

When we focus on a specific element in the picture, the only other parts of the image that are equally in focus are in the plane of focus which is seldom flat (although it's flatter in macro lenses). If you focus on a human or animal eye it might be very sharp but the vast majority of the image will be out of focus to some degree, where sharpness doesn't exist.

Only parts of the image within the DOF will *appear* to be sharp. Everything else in the image closer to or further from the camera than the focal plane is progressively less in focus until you reach the near and far limits of the DOF.

DOF is affected by the crop factor of the sensor (assuming you use the entire image), lens aperture, focal length, and focus distance. This assumes average vision that the print will be viewed from the normal viewing distance.

If you crop the original image, the actual DOF will be reduced by the final crop. For example, cropping a full frame image to an APSC crop (1.5x or 1.6x) will reduce the DOF. The same thing happens if you crop the full frame image on your computer. Either way, the cropped image will need more magnification.

If you think a lot of pixels will allow you to crop an image later on the computer, consider what you will be giving up. When you start with a 36MP image and then crop it by half in both directions, you end up with 9MP and half the DOF. You would be better off using a lens with 2x the focal length.

If we assume that the viewer has 20/20 vision, the DOF is much narrower. Fewer of the elements will seem to be sharp, more of them to be un-sharp or out of focus.

Consequently, it is rare that a lens will produce a totally sharp image. The sharpness in the center or wherever the focus is based will look better than at the edges or in the corners. The out of focus portions of the image will clearly be un-sharp. Testing the sharpness of a macro lens is somewhat pointless. It either works or it doesn't. Macro images are hard to focus and produce a very shallow DOF.

It also matters how the lens is tested for sharpness. If you test it on a distant landscape with the lens focused close to infinity you might get a different impression of sharpness than you would using a flat standard resolution chart in a laboratory at a relatively close distance.

Since there is a potential for so much of the image to be out of focus, determining whether one lens is sharper than another can become an exercise in futility.

Conclusion

If 24MP is all we need, the place to invest is in good lenses and a good printer. Zoom lenses with modest zoom ranges (not super zoom) will work well but prime lenses can be better, lighter, smaller and less expensive. Reputable used lenses can save you a lot of money. Even crop sensors work well at 24MP.

Resist peer pressure and advertising.