Understanding Depth of Field

with Ken Reek

Hi, I'm Ken Reek.

I've been taking photographs for nearly 50 years. I also studied professional photography at the Rochester Institute of Technology for two years.

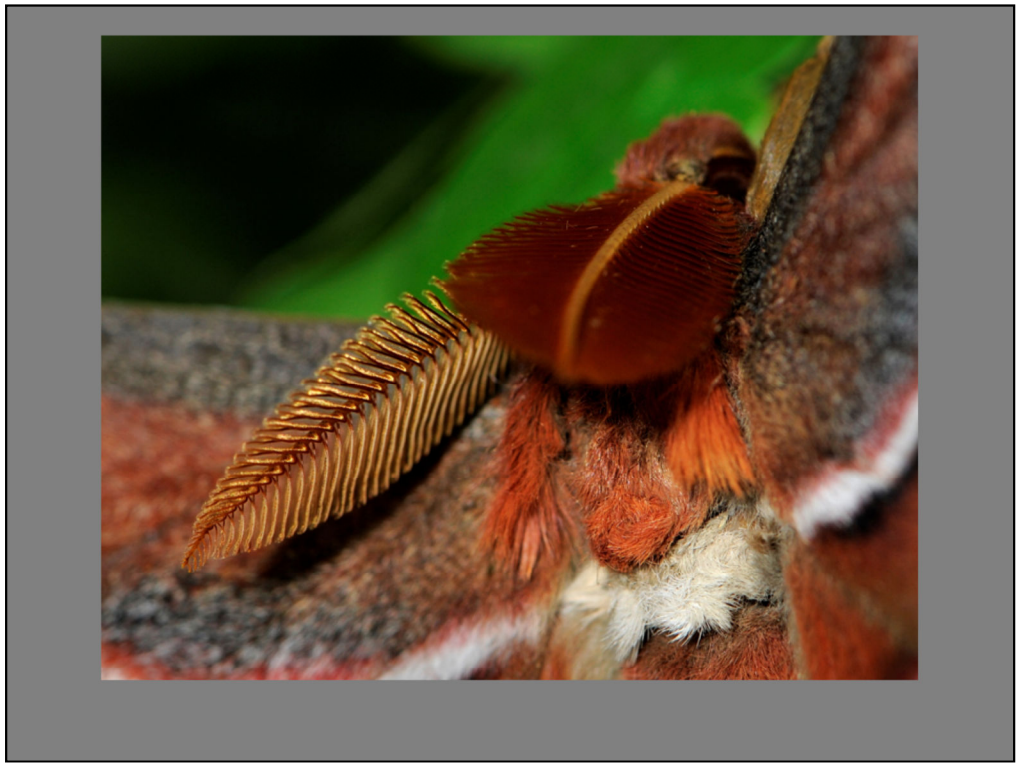
In this presentation I will attempt to explain what depth of field is, and why it occurs.

Definition

- Depth of field: The range of distances from the camera in which objects will be *acceptably* sharp.

The key word is “acceptably” and there is some fuzziness involved—both fuzziness in the pictures, and in the definition itself!

First, let’s look at some examples.



Atlas Moth antennae, Butterfly Conservatory, Niagara Falls Canada

The antenna on the left is almost parallel with the camera and is fairly sharp. The one on the right is pointed directly at the camera

- You can see the small area about halfway down that is sharp.
- Everything in front of and behind this area is blurry.

Very shallow depth of field in this photo.

Great Blue Heron in Montezuma NWR

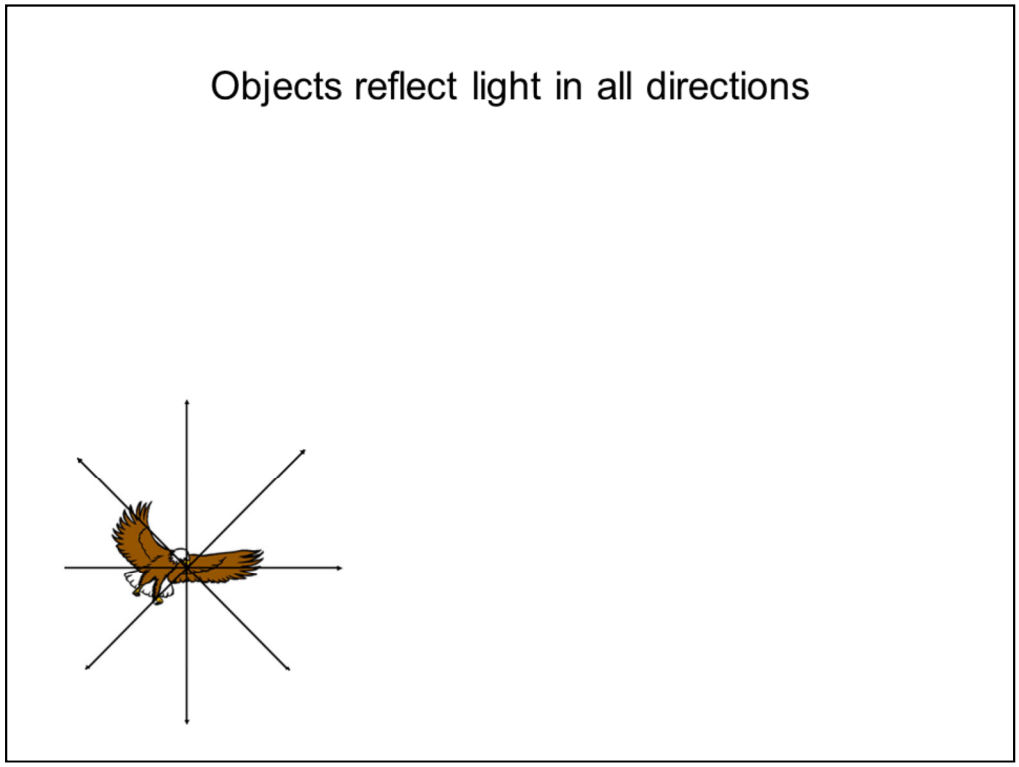
In this photo, you can see the background going out of focus but the foreground all looks reasonably sharp.

More depth of field here than in the previous photo.

Tenaya Lake in Yosemite NP

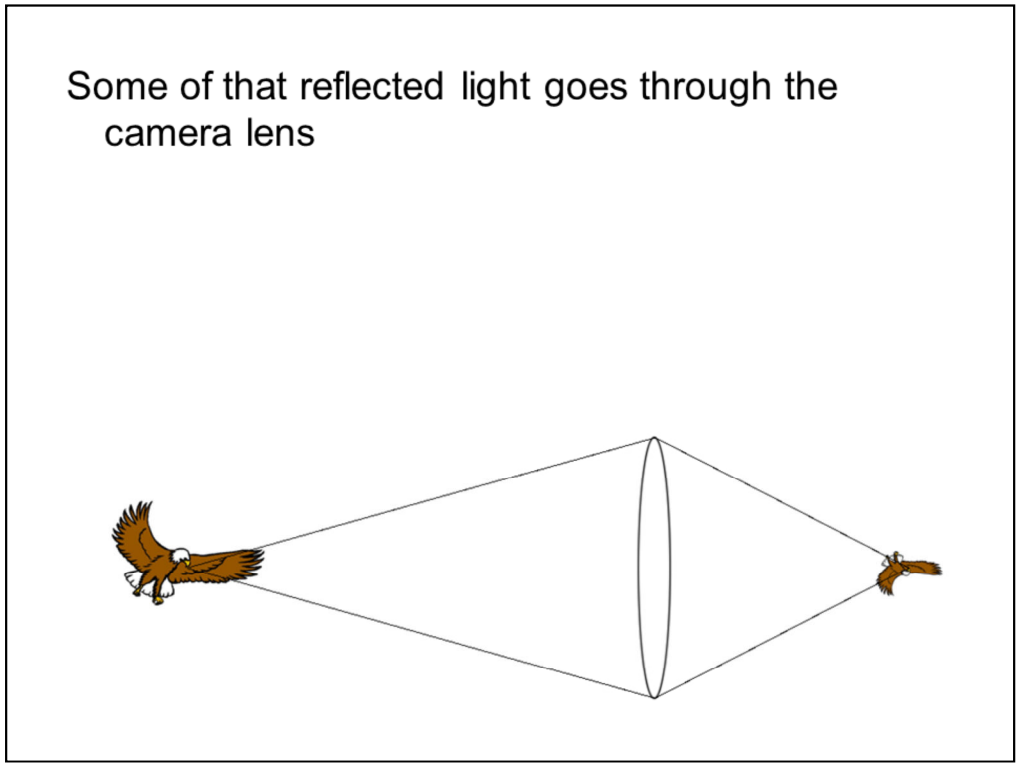
Complete depth of field!

In this photo, everything looks sharp. What causes the difference between these three photos?



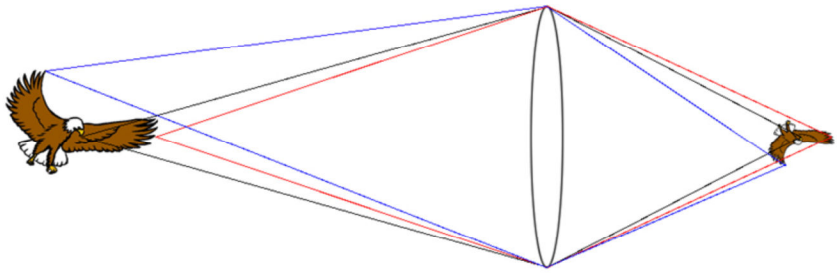
When light strikes an object, the light is reflected in all possible directions.

(There are some exceptions, such as light reflecting off of a mirror, but we can ignore this for now.)



The camera lens gathers a cone of that light from the subject and focuses it to form an image.

- Light from far objects focuses nearer to the lens
- Light from close objects focuses further from the lens

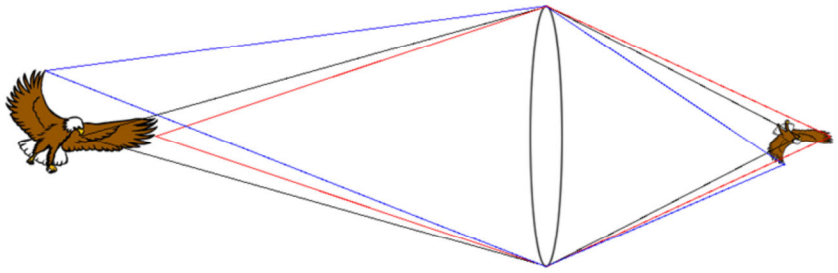


Look at the cones of light coming from two different points on the subject: the blue cone originates at the wingtip that is farther from the lens, and the red cone originates from the nearer wingtip.

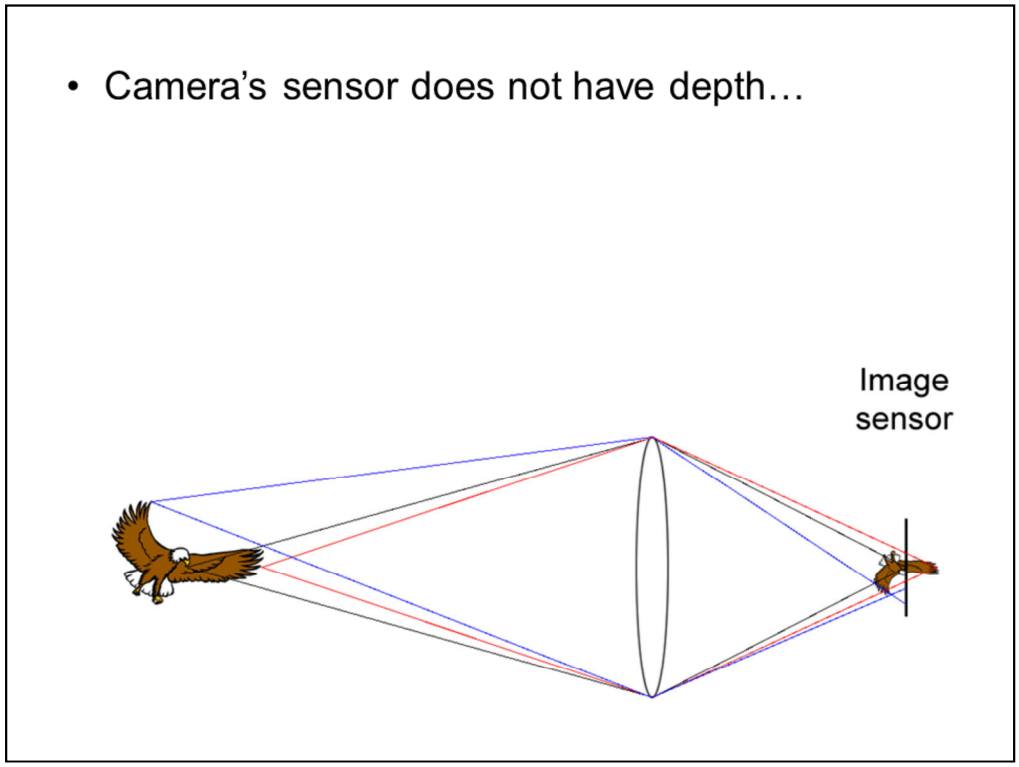
Because of the way the lens refracts (bends) the light:

- the image of far wingtip appears closer to the lens, and
- the image of the nearer wingtip appears further from the lens.

- Light from far objects focuses nearer to the lens
- Light from close objects focuses further from the lens
- The image formed has depth!



If the subject itself has depth (some parts nearer to the lens, some parts farther from the lens), then the image that is formed will also have depth.



However, the sensor (or film) in the camera is perfectly flat.

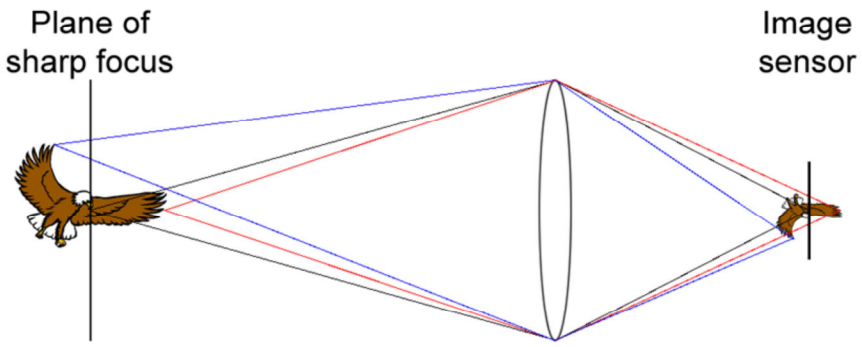
Therefore, only the cones of light that come to a point on the camera's sensor will be perfectly sharp.

The blue lines come to a point in front of the sensor, and by the time these rays reach it they have spread out.

The red lines would have come to a point behind the sensor, but they hit it before they have done so.

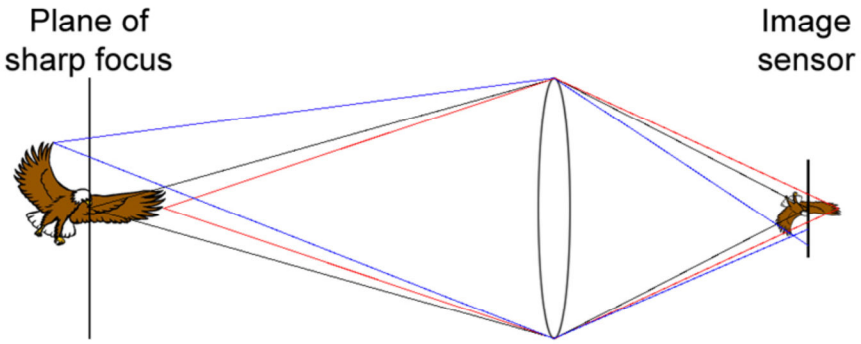
In each of these cases, the image that the sensor sees is a circle rather than a point—it is not sharp.

- Camera's sensor does not have depth…
- Only one plane of subject—one distance from the lens—is in perfect focus



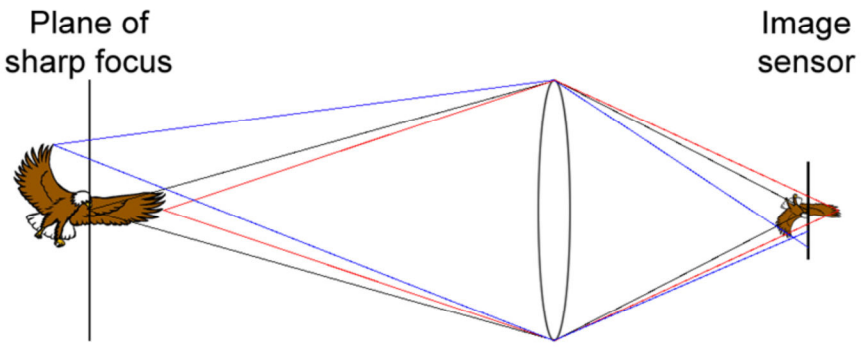
Perfect focus occurs only when light from a point on the subject is focused to a point on the sensor.

- Light originating nearer and further from this plane will be *circles* rather than *points* on the sensor



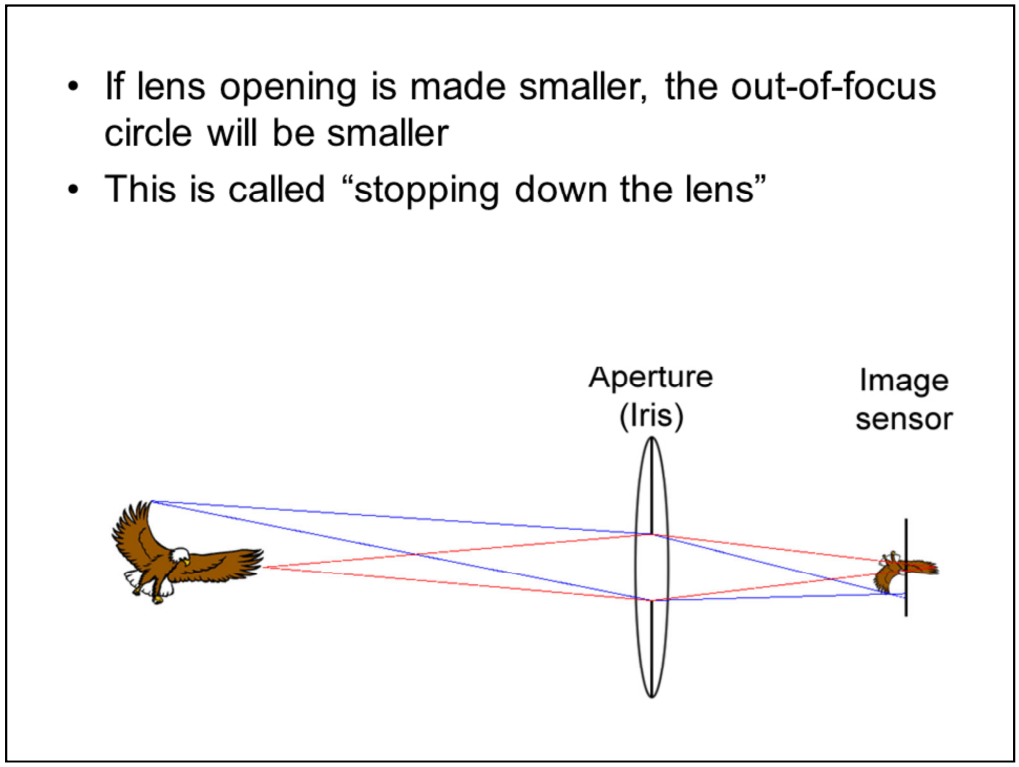
These circles are called the “circle of confusion.”

- Light originating nearer and further from this plane will be *circles* rather than *points* on the sensor
- If these circles are small enough, the image will appear to be in focus



If these circles are small enough, we won't be able to see them and the image that they are forming will appear to be sharp.

(This is the "fuzziness" in the image that I referred to earlier.)



Lens has an iris just like your eye (called the *aperture*). The *f-stop* is a measure of the size of the opening in the aperture.

Look at how closing the aperture (called *“stopping down the lens”)* makes cone of light that passes through the lens narrower.

The resulting out-of-focus circles on the sensor are now smaller, thus they appear sharper in the image.

So: smaller lens openings (larger *f* numbers) result in images with more depth of field.

To get images with more depth of field, why not stop the lens all the way down all the time?

That would require:

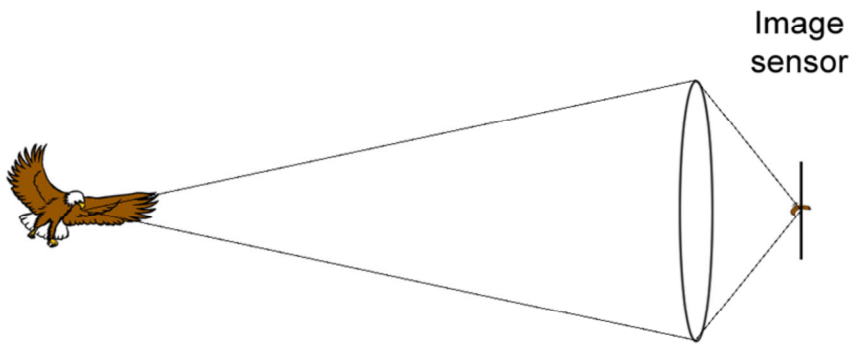
- More light on the subject –or–
- A slower shutter speed –or–
- A more sensitive sensor

There are problems with each of these approaches.

1) You usually don't have control of how much light is on the subject (except when you use a flash).
2) A slower shutter speed increases the risk of blurriness due to camera shake.
3) As you crank up the sensitivity of the sensor, the amount of noise increases.

Wide angle lenses project a smaller image

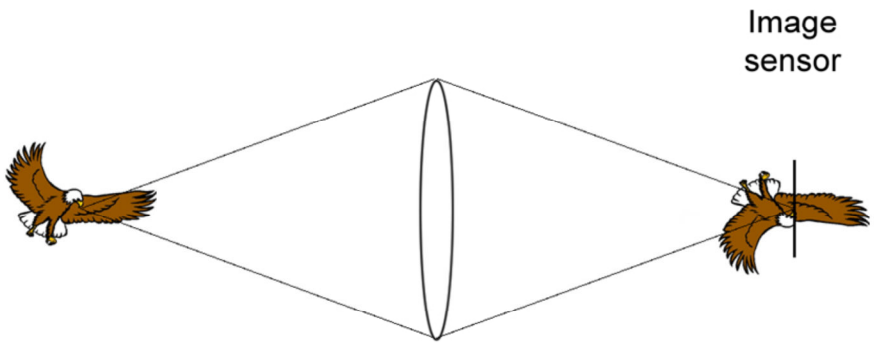
- The image formed is not as deep: out-of-focus points are nearer to the sensor, so …
- That makes the circles smaller, so …
- Depth of field is better



Wide angle lenses produce more depth of field than normal or telephoto lenses.

Telephoto lenses project a larger image

- The image formed is deeper: out-of-focus points are further from the sensor, so …
- That makes the circles larger, so …
- Depth of field is worse



Conversely, telephoto lenses produce less depth of field than normal or wide angle lenses.

Subject distance affects the depth of field.

- Distant subjects project a smaller image, so…
- Depth of the image is smaller, so…
- Circles for out-of-focus parts are smaller, so…
- More of the subject is in acceptable focus

The subject distance also affects depth of field: there is more depth of field with distant subjects.

Subject distance affects the depth of field.

- Near subjects project a larger image, so…
- Depth of the image is larger, so…
- Circles for out-of-focus parts are larger, so…
- Less of the subject is in acceptable focus

Conversely, there is less depth of field with closer subjects.

Now let's look at the photos we saw earlier (plus a few more) and analyze why the depth of field is what it is.

Wide angle lens (24mm)

Stopped down to small aperture (f/13) – lens opening is about 1 ¾ mm

Nothing is very close to the lens

Result: huge depth of field.

Bull elk, Yellowstone NP.

Telephoto lens (300mm)

Large aperture (f/4.8) Lens opening is about 60 mm

Foreground is very close relative to the elk, and the background is much further away than elk.

Result: shallow depth of field.

If background and foreground were both sharp, the elk would not stand out like he does here.

The size of the print matters, too

- In smaller prints, the out-of-focus circles are physically smaller, and look sharper
- In larger prints, the out-of-focus circles are larger and more noticeable

How you view the image also affects the depth of field!

- In large prints (or a large projected image), everything is larger—so the out-of-focus circles are larger.
- Result: the image appears to have shallower depth of field.
- In small prints (or a small projected image—such as when you look at an image on the camera's screen), everything is smaller—so the out-of-focus circles are smaller.
- Result: the image appears to have deeper depth of field.

The size of the print matters, too

- In smaller prints, the out-of-focus circles are physically smaller, and look sharper
- In larger prints, the out-of-focus circles are larger and more noticeable
- However, if you view a large print from far away, the circles appear smaller and less noticeable!

But viewing distance also matters!

- Viewed from up close, everything looks larger: less depth of field.
- Viewed from afar, everything looks smaller: more depth of field.

Summary: Factors That Determine Depth of Field

- How far the lens is stopped down
- Focal length of the lens (tele/wide angle)
- Subject distance
- Size of the print
- Viewing distance

The depth of field that you perceive when viewing an image is affected by all of these factors!

Depth of field is not determined solely by camera settings—this is the “fuzziness” in the definition of depth of field that I referred to earlier.

What Does This Mean For You?

- If your camera lacks manual exposure controls, all you can control is the focal length of the lens.
- To *increase* depth of field, move closer to subject and use a wide-angle setting
- To *decrease* depth of field, move further from subject and use a telephoto setting

Without manual controls, there is little you can do to control depth of field when taking the picture.

Note that moving closer or further from the subject will change the perspective of the image—this technique therefore may not work with some images.

What Does This Mean For You?

If your camera has manual exposure controls, learn how to use them.

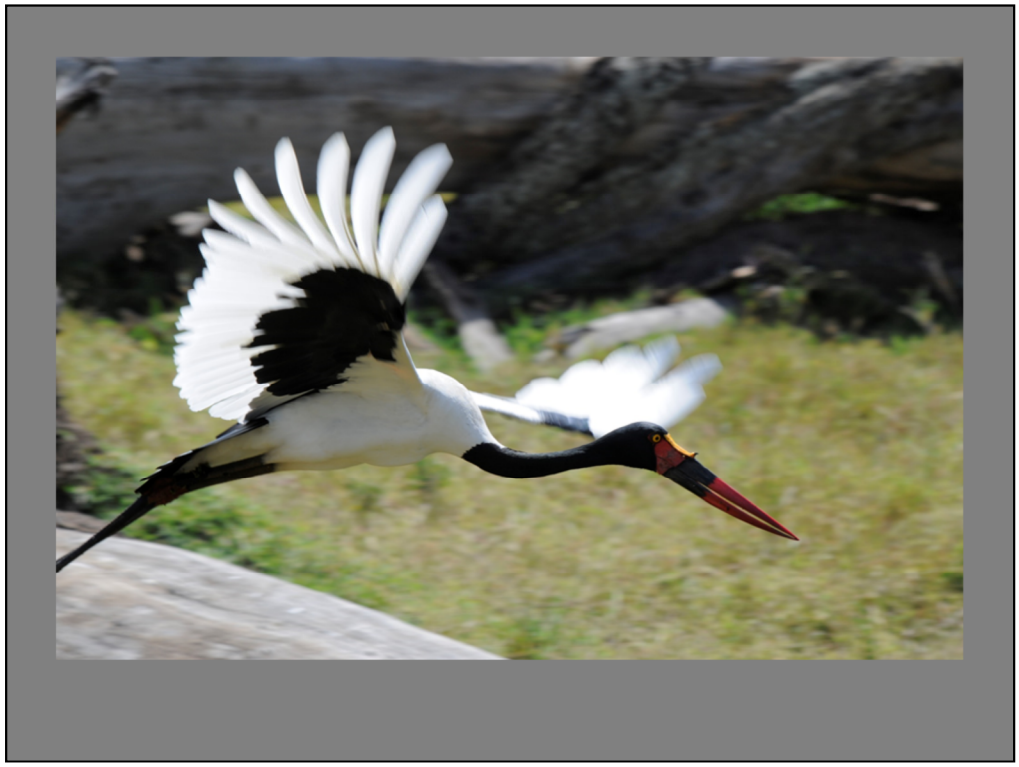
- Use a smaller aperture (f-stop) to increase depth of field –or–
- Use a larger aperture to decrease it and isolate your subject from the background

If your camera has manual controls, you can control the *f*-stop to affect the depth of field in the image.

You can probably also control the shutter speed and ISO (a measure of the sensor's sensitivity to light) to increase this ability.

If an image is brightly lit and you want shallow depth of field, use a large aperture and:

- Increase the shutter speed to obtain the correct exposure, or
- Decrease the ISO to obtain the correct exposure, or
- Some combination of both.



Let’s look at a few more photos.

Telephoto lens (340 mm)
Aperture: *f*/9.5

In this case, the very shallow depth of field is a result of the subject being fairly close.

The depth of field is actually a little deeper than it appears: the blurring of the wingtips is due to the bird’s motion.

Any Questions?

See more of Ken's photos at
www.KMRConsulting.com/photography

I hope this was useful! Thank you for your attention.