Chapter Two – Understanding Aperture

Aperture

In its most basic definition, **APERTURE** simply means a hole through which light travels. As far back as 500 BC people in China were commenting on the fact that light passing through a small hole in a piece of fabric or through a wicker basket sometimes produced an inverted image on another surface.

Discussion of this phenomenon continued throughout history and led to the first "pinhole" camera in 1850 created by Scottish Scientist Sir David Brewster.

To learn more about the history and evolution of Pinhole Cameras check out http://en.wikipedia.org/wiki/Pinhole_camera

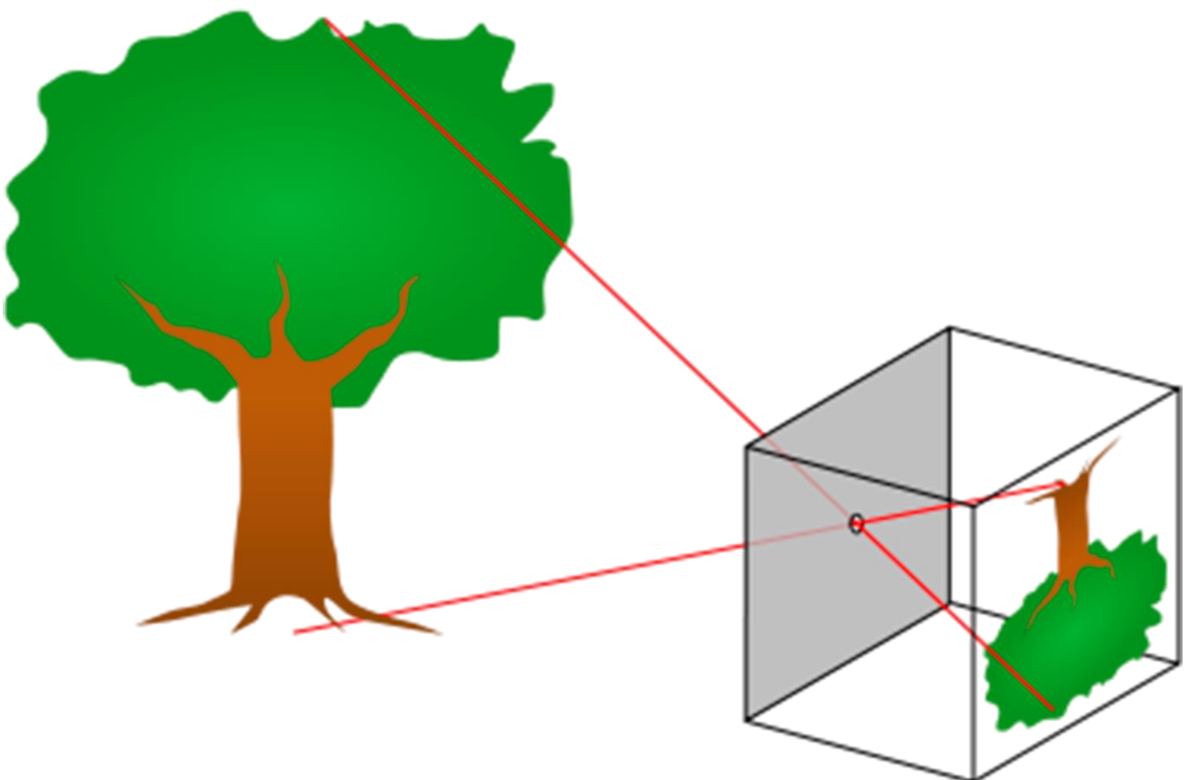
Pinhole Cameras – Back to Basics

The image above was taken by Ewan McGregor and appears on the Wikipedia page related to the link above. It is the result of a twenty-minute exposure with a pinhole camera.

Most people are surprised to learn that a camera doesn't require a lens – just a small hole – in order to capture an image. They are even more surprised to learn that pinhole cameras are more than just a rudimentary tool. They can produce extremely sharp images and they still have a place in modern photography.

The Physics of Light

If you understand what happens when light passes through a hole, you will be in a better position to master the more subtle, creative aspects of photography.



Wikipedia Commons Image

When light passes through a small hole, it produces an inverted image on a surface at some distance from the hole. The image is inverted because light travels in straight lines.

Imagine sunlight hitting a point on a leaf at the top of a tree. The surface of the leaf will absorb some of the light and reflect the rest away from it. Some of that reflected light then passes through the pinhole in a straight line from that specific point on the leaf and strikes the surface at the back of the camera box. Because the light is traveling in a straight line, points on the top of the tree will project to the bottom of the box, and points at the bottom will project to the top. This results in an inverted image on the back of the box.

If a digital sensor (or a piece of film) is placed at the back of the box, this image can be recorded.

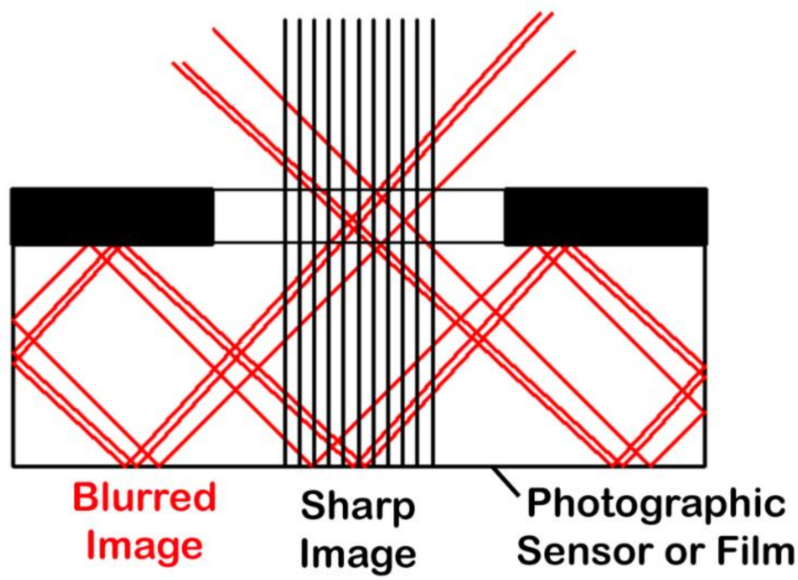
Why Images Blur

When a ray of light enters the box, some of its energy will be absorbed by the surface that it strikes. The light energy that is not absorbed by the film or sensor is free to bounce around the box like a ball. This additional light causes some blurring of the otherwise crisp image.

As you might expect, the less light that we let into the box, the sharper the image will be, but we still need to let in enough light to create a bright image.

Controlling the total amount of light that passes through the pinhole is the job of the shutter and will be discussed in more detail when we discuss **SHUTTER SPEED** later in the book.

Next, let's look at what happens when the hole — or **Aperture** — gets larger. Rays of light that pass through the Aperture perpendicular to the Sensor create a sharp image, while rays of light that enter at an angle bounce around the enclosure and blur the image.



The Big Takeaways

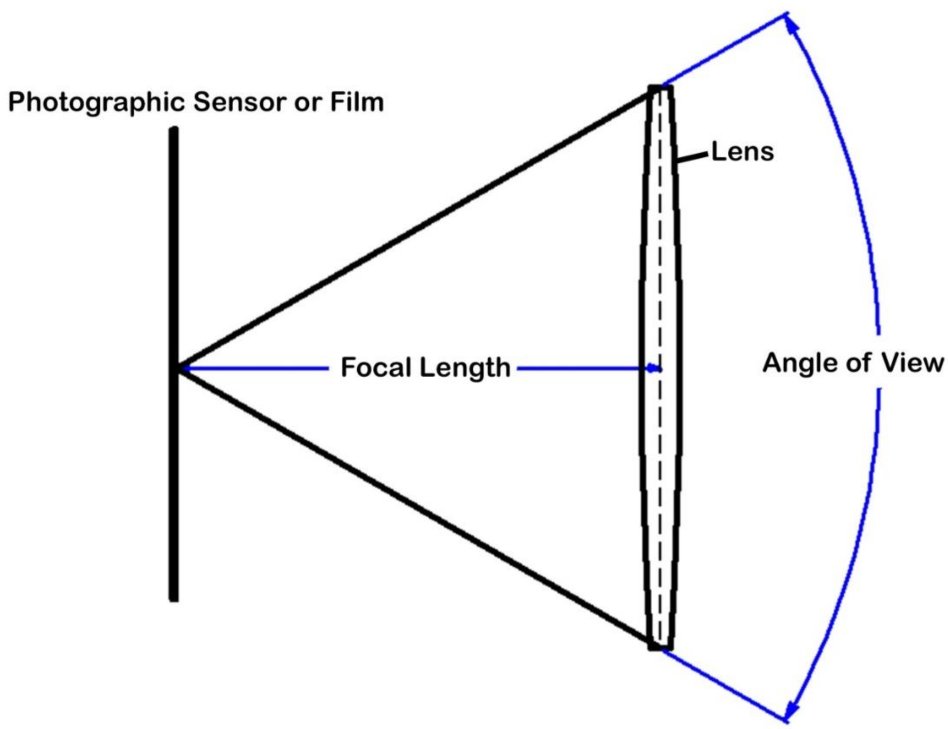
Before we move on to Focal Length, let's take a moment to reflect on what we have learned from Pinhole Photography:

- You don't need a lens to take a photograph.
- Small Apertures produce sharp images.
- Large Apertures produce images with blurred areas.

This fundamental relationship is what controls **DEPTH OF FIELD**, a photographic term that indicates how much of the image is sharp and how much is blurred.

Focal Length and the Math of *f*-stops

Before we discuss how to adjust your aperture, we need to talk about **FOCAL LENGTH**. Focal Length is the distance from the mid-plane of a lens to the camera's sensor or film.



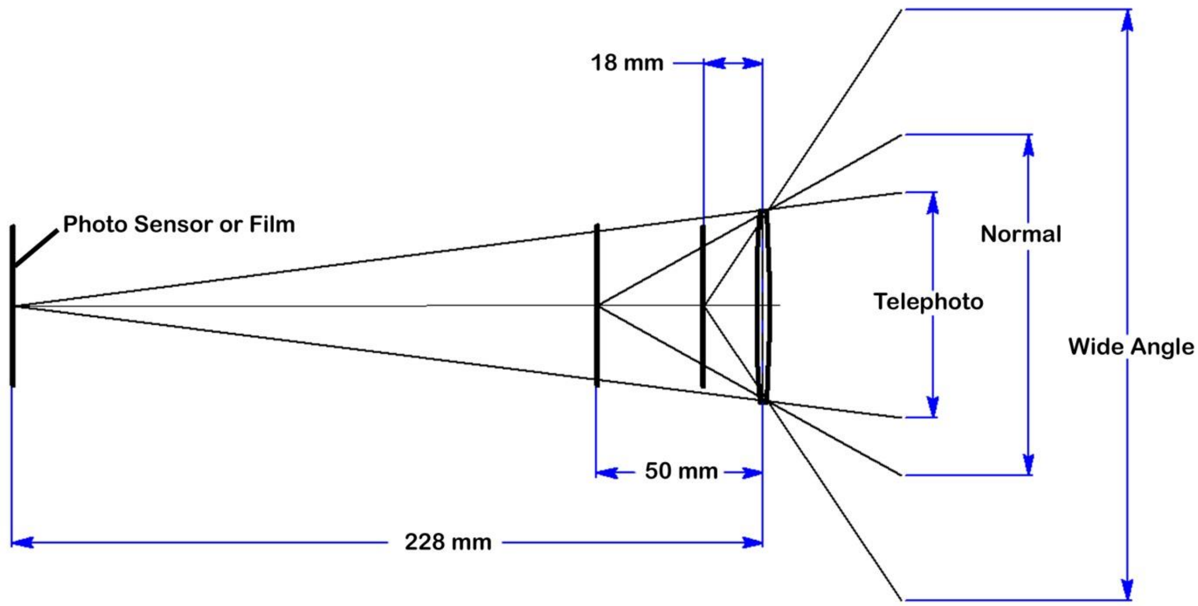
The Focal Length determines how much of the scene in front of the camera can be captured by the sensor. In general, camera lenses fall into three main categories:

- **Wide-Angle Lenses:** Lenses with a Focal Length of less than 35 mm are considered Wide-Angle Lenses. They exaggerate the size of subjects that are close and shrink objects at a distance. This is why wide-angle lenses are so popular with landscape photographers.

- **Normal Lenses:** Lenses that are in the 50 mm range are considered Normal and simulate human vision.

- **Telephoto Lenses:** Lenses that have Focal Lengths greater than 70 mm are considered Telephoto Lenses. Telephoto lenses act like magnifying glasses since they focus on such a limited area of the scene. They also tend to compress distances. In some cases, objects that are miles away look like they are very close to objects that are only a few yards away.

The following diagram shows the relationship between focal length and angle of view for three different lenses – an 18 mm Wide-Angle Lens, a 50 mm Normal Lens, and a 228 mm Telephoto lens. The second image shows the effects in real life for various focal lengths.

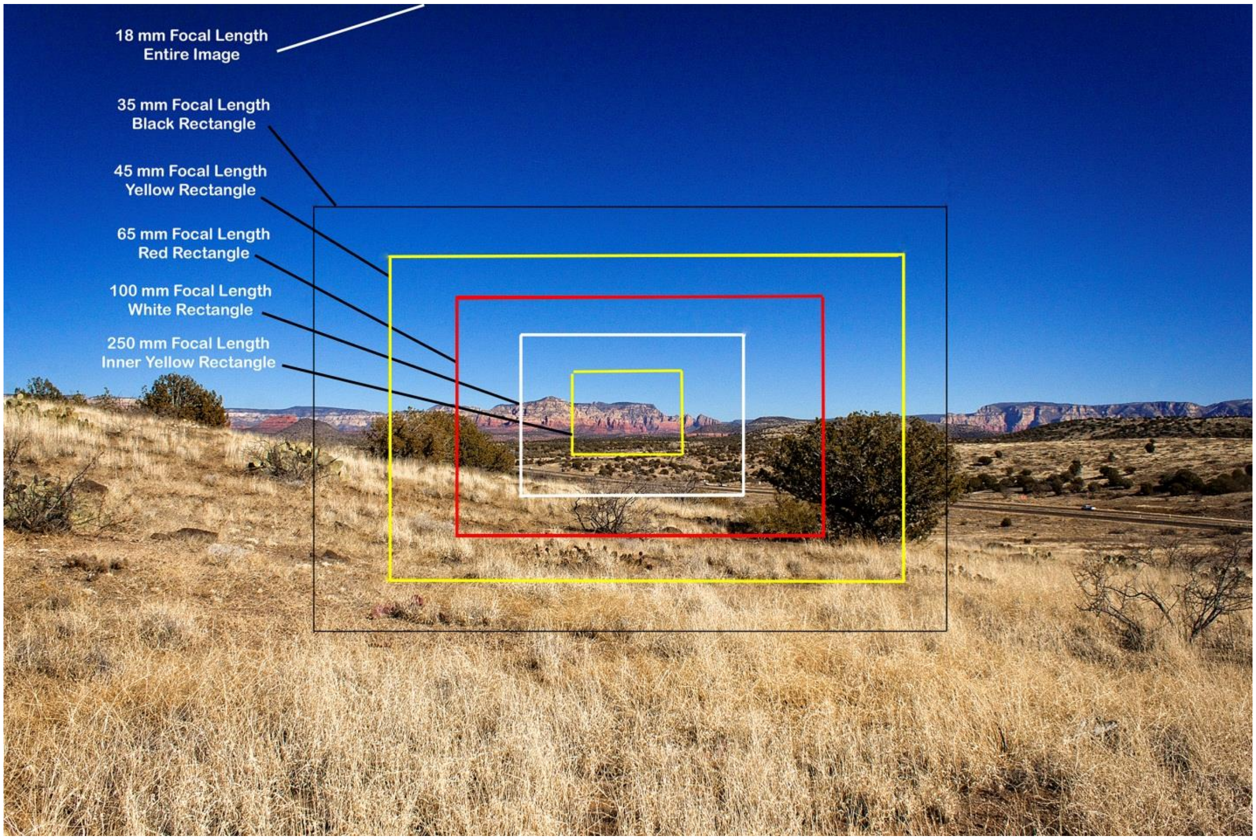


As you can see in the following image, the amount of the scene that can be captured by a wide-angle lens at 18 mm is dramatically greater than even a 35 mm focal length. This is why wide-angle lenses are so popular with landscape photographers.

The image below indicates how much of the large image you would see in your viewfinder for each focal length on the chart.

The entire image corresponds to an 18mm focal length. The focal lengths for the smaller rectangles are:

35 mm – Black Rectangle
45 mm – Larger Yellow Rectangle
65 mm – Red Rectangle
100mm – White Rectangle
250 mm – Smaller Yellow Rectangle



In general, lenses with a Focal Length of less than 35mm are considered Wide-Angle Lenses. Lenses that are in the 50 mm range are considered Normal and simulate human vision. Lenses that have Focal Lengths greater than 70 mm are considered Telephoto Lenses.

Wide-Angle Lenses exaggerate the size of subjects that are close and shrink objects at a distance.

Telephoto lenses act like magnifying glasses since they focus on such a limited area of the scene. They also tend to shrink distances. In some cases, objects that are miles away look like they are very close to objects that are only a few yards away.

The Image above was taken with a wide-angle lens. Notice how the twisted juniper trees in the foreground stand out. Because they are close to the camera, they are somewhat magnified compared to the large red rock formation behind them.

In the image above, the large rock formation is about a mile from the people but appears to be much closer. This is the result of using a telephoto lens. Besides enlarging objects, it compresses distance.

Aperture Settings – *f* Stops

As a result of our discussion of Pinhole Cameras and Focal Lengths, we are now in a great position to take the mystery and intimidation factor out of adjusting **APERTURE** and **DEPTH OF FIELD**.

Most people are confused by the fact that large *f*-stop numbers indicate small holes and vice versa. This is because an *f*-stop number is actually a fraction. Just as 1/10 is larger than 1/1000, so *f*/8 is larger than *f*/22.

The actual meaning of the number (fraction) is:

Focal Length (*f*) / Diameter of the Aperture (Hole)

So if we have a lens with a Focal Length of 50 mm and the Aperture is set to an opening with a diameter of 12.5 mm, we have

50 mm / 12.5 mm = *f*/4

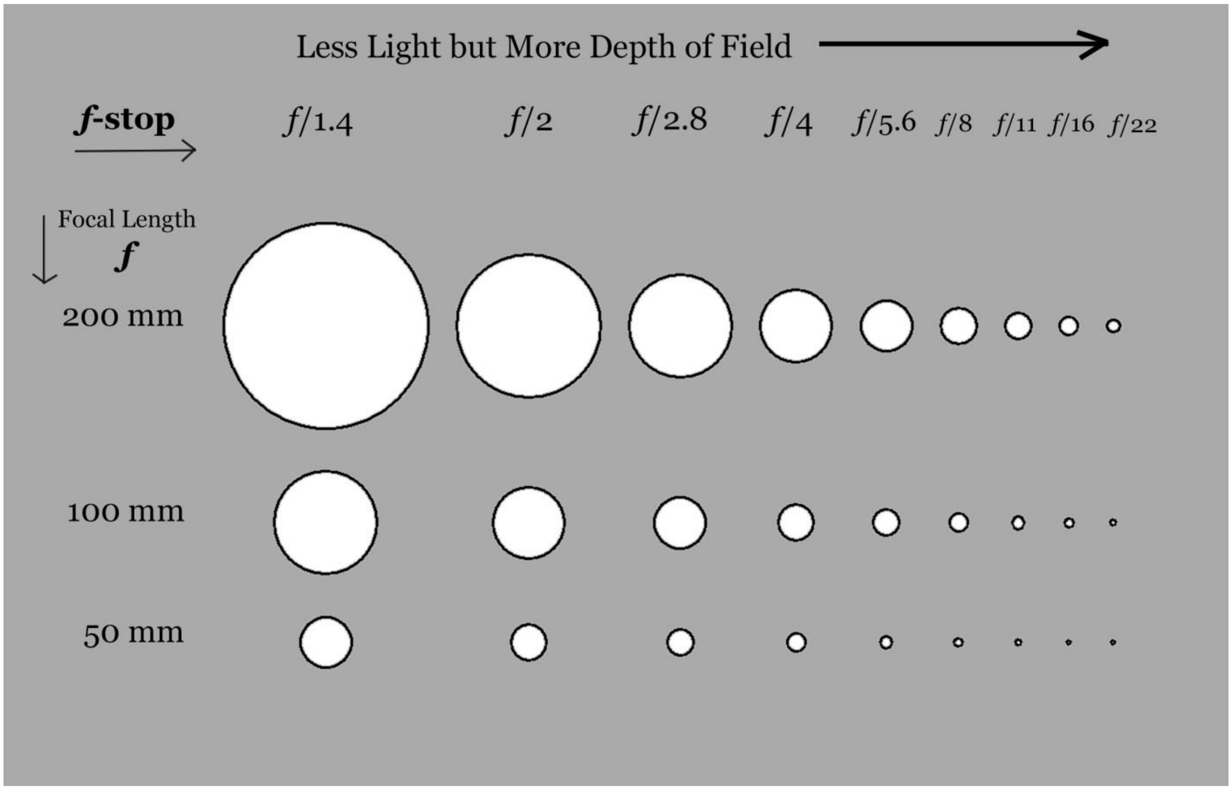
The importance of the *f*-stop is its effect on exposure and depth of field. When a photographer says that he has "stopped down a full stop," he means that he has reduced the area (not diameter) of the aperture opening by one-half. Therefore, half as much light is allowed to pass through the aperture to the sensor.

Modern digital cameras allow you to stop up and down in ½-stop and 1/3-stop increments for greater control over Exposure and Depth of Field.

DEPTH OF FIELD is the range of sharp focus in an image. If the aperture opening is large, the image will have soft edges and the background will be blurred. This is the preferred setting for portraits where the person's face is the object and the background is unimportant. The opposite is true of landscape photography. In this case, everything from foreground to background should be in focus. All other situations fall somewhere between these extremes and an experienced photographer will quickly decide the optimum *f*-stop to create the feeling that she hopes to convey.

The actual *f*-stop settings available to you will depend upon the lens being used. If you are using a zoom lens, the Focal Length of the lens will change as you zoom in or out. The lens will have a limited number of aperture opening sizes that it can produce, and so the *f*-stop values available will vary as the Focal Length changes.

As you can see from the following chart, the actual size of the Aperture can vary significantly depending upon the Focal Length of the lens and the *f*-stop selected.



Digital SLRs also let you choose fractional stops for greater control. This selection can be made with the camera's menu selections. The following chart shows the values that will be available based on your selection.

	One Stop								Two Stops															
Full Stops	2.8				4				5.6				8				11			16				22
1/2 Stops	2.8		3.3		4		4.8		5.6		6.7		8		9.5		11	13		16		19		22
1/3 Stops	2.8	3.2		3.5	4	4.5		5	5.6	6.3		7.1	8	9		10	11	13	14	16	18		20	22

The full range of choices will not be available for all lenses. For any given lens, there will be a maximum and minimum Aperture value. For zoom lenses, these min and max values will change as you change focal length (zoom in and out).

Wide Apertures have small *f*-stop numbers (like *f*/1.4 or *f*/2.8) and are preferred for portraits and close-ups of flowers and plants.

Medium Apertures often produce the best quality images when Depth of Field is not critical.

Small Apertures have large f-stop numbers (like *f*/16 or *f*/22) and are preferred for landscape photography.

Although the image will theoretically get sharper as the aperture gets smaller, this is not necessarily the reality. Diffraction effects cause some deterioration of the image at very small sizes. Most lenses have a minimum aperture of f/22 but some go to f/32.

Examples of Depth of Field

A shallow Depth of Field is just as desirable when photographing flowers as it is for portraits. The details of the background are unimportant but the colors often enhance the image of the flower. The image below was taken with a 50 mm lens, *f*/1.8, and ISO 200. This is a very large aperture setting and allowed me to have a faster shutter speed. Flowers move with even the slightest breeze and I live in a windy climate. We will talk about Shutter Speed in the next chapter, so for now I will simply state that the speed was 1/50 sec. This is actually slower than I would normally use for this type of image but it worked out ok.

BOKEH is a term closely associated with a shallow depth of field. Basically, it is the esthetic quality of the blurred background. If a lens has a good bokeh it means that the blurred background is very even in color distribution. A poor bokeh, on the other hand, is very splotchy.

The image above was taken with settings of *f*/4, 1/500 sec, and ISO 400, at 55 mm focal length. Although f/4 is in the large aperture range, the people in the background are still a serious distraction. The dancer's movement is far too fast to use anything other than a fast Shutter Speed. For the same reason, I couldn't have used a lower *f*-stop – I wanted the Dancer and his costume to be sharply focused. A shallower Depth of Field might have missed some details. When this image is enlarged, you can see the reflection of the audience in the bells on his feet.

With the help of Photoshop, I was able to eliminate the audience and get the result that I was looking for.

Thanks to this image I was included in the **Sedona Area Guild of Artists** list of
Top Artists of Sedona 2012

The image below is an example of a large Depth of Field.

Everything is in focus from foreground to background. This is standard procedure for landscape images. The settings are *f*/20, 1/8 sec, ISO 100, and 50-mm focal length. This is actually a composite of about 25 images. The result is a field of view similar to using a wide-angle lens at about 18 mm focal length.

In order to master Aperture and Depth of Field settings, you need to understand how Aperture is affected by Shutter Speed and Exposure. So, let's move on to those topics and come back to this after we have all the pieces of the puzzle lined up.