

# IR Photography

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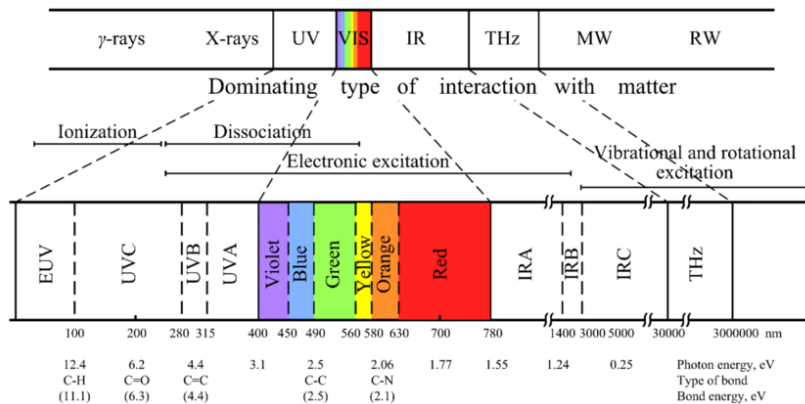
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# What is IR (Infrared) Photography

Infrared (IR) images are taken using longer wavelength light than is visible by the human eye.

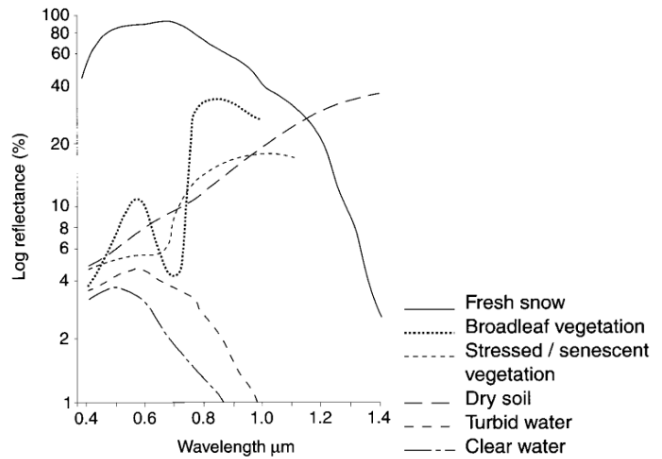
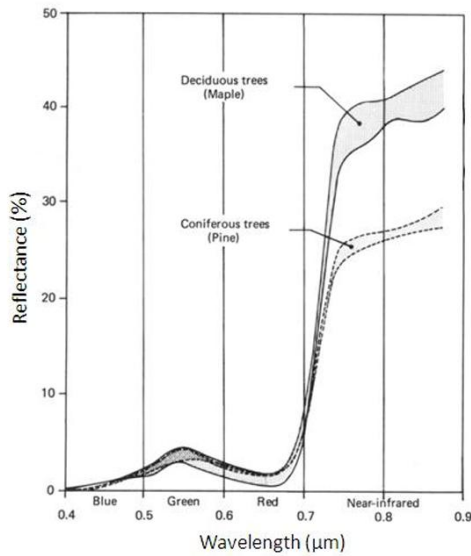


Wavelengths used in infrared photography run from roughly 700nm to 1000nm whereas the visible spectrum runs from about 380nm to 780nm.



Infrared light is radiated by hot objects – the hotter the surface, the shorter the wavelength of light it emits. IR can also be reflected. Since they record heat, specialized long wavelength IR cameras that can record wavelengths from 1,000nm to 14,000nm are used in energy audits to detect warm or cold spots in a building. However, to get objects to emit a noticeable amount of IR light in the range of wavelengths most digital camera sensors can detect requires heating them to at least 500°F. So, unless you are photographing a flame or very hot metal, what you are photographing is IR reflected from a light source such as sunlight or some other light source. To confirm this, I tried photographing two teacups using IR, one filled with ice water and the other with very hot water and there was no difference in the image.

To varying degrees, vegetation absorbs visible light and reflects IR. Water, on the other hand, reflects very little IR so it appears dark. Here are graphs of reflectance at different wavelengths for different subjects.



## What IR Filter Should You Use

To take IR photographs, you need to place an IR-pass filter somewhere in the light path before it hits the sensor. An IR-pass filter is one that passes IR light and blocks other wavelengths to which the camera is sensitive. By contrast, an IR-cut filter blocks IR light and passes visible light. These filters are available with different cutoff wavelengths such as 590nm, 720nm or 830nm. The best filter to use depends on the type of IR photography you plan to do.

### Black and White IR

For black and white IR photography, the most common filters are 720nm and 830nm (or sometimes 850nm), and either one can produce good results. The “standard” IR filter is 720nm.

A 720nm filter passes a little more deep-red visible light than an 830nm filter, but the difference in the resulting images is usually quite subtle with the 830nm producing slightly more contrast. Here is an example of the same scene photographed using each filter and converted to black and white, with the results adjusted to have the same black and white points.



720nm



830nm

Because it passes more light, a 720nm filter produces images almost 2 stops brighter, depending on the scene you are photographing. In the example above, the 720nm image was shot with a 1/80 second exposure (at f/11 and ISO 100) while the 830nm image required 1/20 second to produce approximately the same image brightness.

Some images taken using a 720nm filter retain a little color – for example, clear blue skies are a little yellow while everything else is a little cyan. An 830nm filter on the other hand produces essentially monochrome images. By boosting the saturation during the processing of 720nm images, sometimes you can exaggerate their color enough to make selective editing of differently colored areas useful. For example, while converting the image to monochrome, you can make different tonal adjustments to each color. Or, you can create masks based on the different colors.

Here is an example of an unprocessed raw file and what it looks like with its saturation turned all the way up:



Raw File



With Saturation Boost

In summary, I recommend using a 720nm filter for most black and white IR photography because its effects are very similar to using an 830nm filter, the exposure times are about 2 stops faster, and you have more flexibility when converting to monochrome.

### **Color IR**

Filters made for color IR photography pass more of the visible light wavelengths along with IR wavelengths. Typical cutoff wavelengths run from about 450nm to 600nm with shorter wavelength cutoffs yielding the most extreme color effects. The filter choice depends on how you plan to process the images and what kind of results you are trying to achieve. While I do not practice color IR photography, if you want to experiment with this, you can find lots of information on the websites of the companies that do IR camera conversions.

### **Previsualizing and Processing IR**

It takes some practice to be able to imagine what a scene will look like in IR light. Ultimately the best way to find a good composition is to look through the viewfinder of a converted camera. However, as a rule of thumb, IR renders the following as light tones:

- Clouds (which reflect heat – hence the greenhouse effect).
- Foliage – Evergreens usually show up darker than deciduous trees since they reflect less IR than broadleaf trees. Moss and lichen also reflect IR but not as much as leaves.
- Anything very hot like an open flame or a bright light source.
- Anything that reflects sunlight.

And the following as dark tones:

- Clear blue skies.
- Water or ice.
- Tree trunks, buildings, rocks, soil and other non-living things.
- Anything in the shade will be darker than in the sun.

Scenes tend to have less dynamic range overall in IR than in visible light. Consequently, when the light is too harsh for normal photography it may still be suitable for IR photography. It also

means you will probably end up stretching the dynamic range of many images and may also need to add local contrast enhancement to bring out details. More on this later.

IR images can be noisier as well, so using a good noise reduction filter early in the raw processing pipeline is often a good idea.

## **Camera Conversions**

Although using an IR pass filter on a regular camera works, most cameras have a cover glass (sometimes called a hot filter) over the sensor that intentionally blocks most UV and IR light from reaching the sensor. Without such a filter, images would be less sharp since UV and IR light focus at a slightly different distances from the sensor plane than visible light. In any case, because the hot filter blocks most of the IR light, you need very long exposure times when using an IR filter on an unmodified camera.

To get useful exposure times, you need to have your camera body converted to be sensitive to IR. This involves replacing the hot mirror with a different filter that lets through IR light. Normally this is done by a mail-in service. If you are interested in getting into IR photography, consider this option the next time you upgrade to a new camera body, instead of selling the old one.

There are several options when it comes to IR conversions.

### **1 - Full Spectrum Conversion**

Replacing the cover glass over the sensor (also called a hot mirror) with one that passes UV, IR and visible light is called a full spectrum conversion.

A full spectrum conversion lets you continue to use your camera for normal color photography although to do so, you will need to use a filter that blocks UV and IR light from reaching the sensor and blurring the image and throwing off the color balance. For IR photography you use an IR-pass filter that blocks visible and UV light and passes only IR. By switching filters, you can vary the cutoff wavelength to experiment with different effects. Using a filter in front of the lens can be a problem with certain wide angle lenses whose front element protrudes and therefore do not accept screw-in filters. You can still use these lenses if you use a clip-in filter that goes behind the lens – more on this later.

When photographing using visible light, it is important to use the correct filter to pass visible light and block UV and IR – this filter must match the spectral response of the hot mirror that was removed from the sensor. Make sure you purchase this filter from the same company that did the full spectrum conversion. Third party filters sold as UV/IR pass usually do not block the right part of the spectrum, and as a result the color balance will be way off when using the camera with visible light. The hot mirror replacement filter should have a definite blue-green cast like this:





## **2 - Conversion to IR**

This involves replacing the cover glass over the sensor with an IR pass filter, making your camera permanently dedicated to IR photography with a specific cutoff wavelength. The advantage of this method is that you do not need to use filters on your lenses. The disadvantage is that the camera can no longer be used for normal color photography, and you cannot experiment with different filters.

## **3 - Conversion to Monochrome**

Removing the Bayer color filter array (CFA) from the sensor and replacing the cover glass with one that passes both IR and visible light makes your camera record only black and white images.

This more extreme option converts your camera to monochrome-only, similar to a Leica Monochrom, where every photo site now captures the same wavelengths. You use an IR-pass filter to take black and white IR photographs and an UV/IR-cut filter to take black and white photos with visible light. Removing the color filter array makes the camera a little more sensitive to light and provides a small but noticeable increase in resolution. The disadvantages are that you can no longer use the camera for normal color photography and that processing the images takes an extra step to convert the raw monochrome images to color DNG files before you can process them further. In addition, you lose the ability to perform phase-detect autofocus.

## **4 - Conversion to Monochrome IR**

Removing the color filter array from the sensor and replacing the cover glass with an IR pass filter is similar to the previous option, except you can only use the camera to take black and white IR photographs with a specific cutoff wavelength, but you don't need to use a filter on your lenses.

## IR Filters

If you opted for a monochrome or full-spectrum conversion, you need to use IR pass or IR cut filters to select the wavelengths you want to photograph. There are two types of filters you can use:

### Clip-In Filters

Clip-in filters mount in the camera body, between the sensor and the lens:



They are available for most common cameras and come in a full range of spectral characteristics. The advantage of clip-in filters is you don't need to get a filter for each of your lenses. The disadvantage is that it is tricky to switch filters and consequently not recommended to attempt this in the field. This option is better suited to situations where you want to go out and shoot only visible or IR and don't need to switch back and forth. Clip-ins do need to be removed to clean the camera sensor and then re-inserted since dust can and will make its way behind them.

### External Filters

External filters simply attach to the front of your lens. You either need a set of filters for every size lens you have, or you need to use step-up rings. If you use a step-up ring, you will not be able to use the lens hood that came with the lens. Some wide-angle lenses have a protruding front element and do not accept available IR filters.

Over the past few years, I have had several camera bodies converted to IR.

A Panasonic GH-3 micro four thirds camera converted by LifePixel (option 2 with a 720nm filter). This camera produced some very nice IR images and got me started on a long journey. I later sold this camera after getting a much higher resolution one converted (see below).

A Sony A7RII that was converted by Monochrome Imaging (option 3). The monochrome Sony A7RII is a much higher resolution camera than the GH-3 and has produced some very fine results.

A Sony A7RV converted to full spectrum by LifePixel (option 1). This lets me shoot either color or IR by switching filters, saving the weight of an extra body if I want to capture both IR and normal color images. The A7RV is however about a stop less sensitive than the monochrome A7RII.

A Panasonic ZS100 converted to IR by LifePixel (option 2 with a 720nm filter). This compact point and shoot with a 25-250mm equivalent lens is small enough to take almost anywhere. Even when I have my full frame cameras with me, I keep the ZS100 in a case on my belt and use it to search for good IR subjects before unpacking the big camera and setting up the tripod.

## Camera Settings

To get sharp, well exposed images, you need to be aware of several differences between IR and visible light photography when it comes to adjusting focus, exposure and white balance.

### Focus

IR light focuses at a slightly different distance from the lens than visible light. Mirrorless cameras that use contrast detection autofocus automatically compensate for this. Similarly, focus peaking works the same for IR and visible light.

Cameras that use phase detection autofocus will not autofocus IR correctly unless your camera is adjusted to provide the appropriate amount of front or back focus. The camera conversion service usually takes care of the adjustment for you, but this can be a problem if you are trying to use the camera for both normal and IR photography. For this reason, it is recommended to use mirrorless camera bodies rather than DSLRs.

### Autoexposure

Being designed to measure visible light, your camera's meter may not measure IR light accurately, and therefore its autoexposure and histogram may be a little off. To avoid this issue, you can bracket one or two stops either way.

Depending on the type of IR conversion you selected for your camera body, the built-in light meter may lead you to consistently either overexpose or underexpose. Using a body converted to monochrome, you may need to underexpose by about  $\frac{1}{2}$  to 1 stop since the color filter array has been removed and consequently more light reaches the sensor. With a full spectrum conversion, you may need to overexpose by about  $\frac{1}{2}$  to 3 stops since the combination of the color filter array and the IR filter reduces the amount of light reaching the sensor. This may also vary with the camera make and model, the IR filter you are using, as well as the subject you are photographing. After working with your converted camera for a while, you will develop a feel for the correct exposure level.

### Custom White Balance

Unless you are using a monochrome-converted camera body, uncorrected IR images will have a strong red cast when viewed on your camera's view screen. To remove this, you can set a custom white balance, assuming your camera supports this feature. Setting a custom white balance involves aiming the camera at a white sheet of paper under normal outdoor lighting conditions and letting the camera determine the necessary correction to make the paper a neutral gray. Once you do this, images on the view screen may still have some residual color, but the red cast should be gone.

### Black and White

If your intention is to produce black and white IR images, after setting a custom white balance, set your camera to display monochrome images on its monitor. This will let you preview a more accurate representation of what the final images will look like.

Once you get the viewfinder to display a good preview image, you may find it convenient to assign the settings to one of your camera's custom modes so you can quickly restore them as needed.

## Diffraction

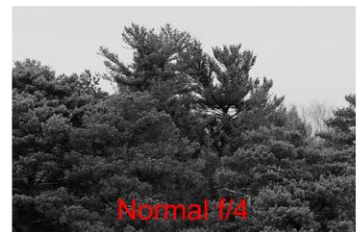
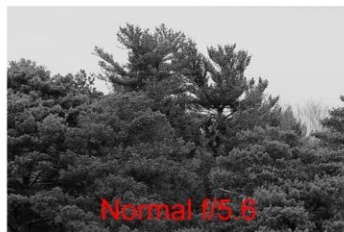
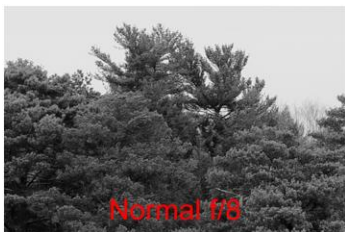
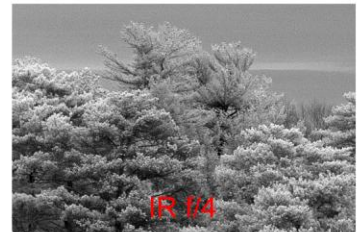
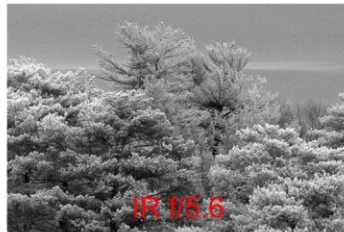
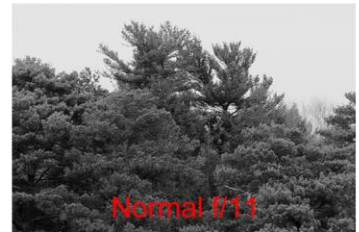
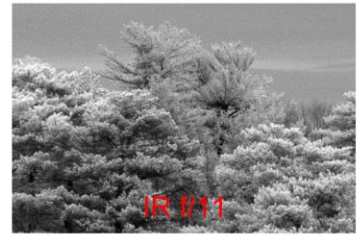
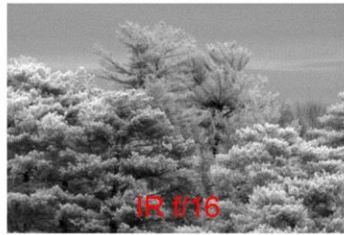
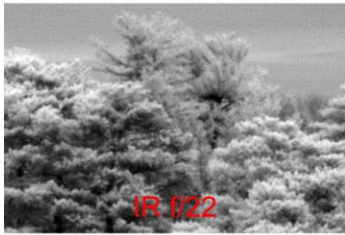
Image blur due to diffraction is proportional to the wavelength of the light. By convention, visible light diffraction is computed using a wavelength of green (550nm) light while IR runs from around 700 to 1000nm, which is about 50% longer, so diffraction blur is correspondingly greater at the same f stop.

For example, using f/16 for IR photography produces about as much diffraction blur as using f/24 for visual light. So, to keep images sharp you need to use wider apertures (lower f numbers) which forces you to deal with a corresponding loss of depth of field. As a result, you may need to focus stack more often, if you want to keep everything in sharp focus.

Here are 100% crops of the centers of some images taken with the same camera (a Sony 42MP full frame converted to monochrome) and lens (Sony 24-70 GM II), comparing Normal and IR diffraction blur at different apertures. First, here is the full frame with the cropped region outlined:



Ignore the unavoidable differences in tonality since IR renders the scene differently.



The bottom line is that if you want avoid diffraction blur, you need to try limit your aperture to around  $f/8 - f/11$  for IR photography. This is roughly equivalent for normal photography to shooting at no more than  $f/11 - f/16$ . Consequently, when shooting IR, you will have less depth of field due to the larger aperture, and you may need to choose between focus stacking or accepting softer images if you need more depth of field.

## Haze Reduction

IR light is scattered by atmospheric haze much less than visible light as illustrated in the examples below that were taken under exactly the same conditions. This means IR can cut through haze to reveal details that might otherwise be obscured. Whether this is an advantage or a disadvantage depends on the effect you are trying to create. Sometimes haze creates atmospheric perspective which adds depth to an image, sometimes it just obscures what you want to photograph.



Visible Light



IR

## Polarizing Filters

Nearly all polarizing filters made for photography act primarily on the visible light spectrum and have little if any effect on IR. While some specialty optical glass manufacturers do make IR polarizing filters, they are expensive and not currently an off-the-shelf item you can order as a camera filter.



## Processing Color IR Images

If your camera conversion retains its color filter array, IR images have a little color to them since the red, green and blue filters each respond differently to the infrared spectrum. The effect also depends on what kind of IR filter you are using. This residual color can be manipulated to colorize the images, although personally I do not find this effect pleasing. You will generally need to set a custom white balance for color IR photography to first remove the heavy red cast. You can usually do this by selecting the color of a white sheet of paper in sunlight. Or you can simply convert the color image to monochrome and render it in the classical black and white. As a starting point for colorizing the image, you can swap the red and blue channels (Transformation/Color/Swap Channels) as this makes the sky look turquoise instead of yellow:



Out of Camera JPEG



Red and Blue Channels Swapped



Converted to Black and White



## Processing RAW files from Monochrome Conversions

If your camera's color filter array was removed, you need to use an application such as Monochrome2DNG to convert your RAW files to monochrome DNG files which you can then open directly with Picture Window or with a program such as Lightroom or Photoshop. Currently, DxO cannot read these converted DNG files. When you export the converted image from Lightroom or open it in Picture Window, the result is a color image even though it contains no color information, so the first step is normally to convert it to 16-bit black and white.

If your camera records in color, you can just open the raw files as you normally would.

## Hot Spots

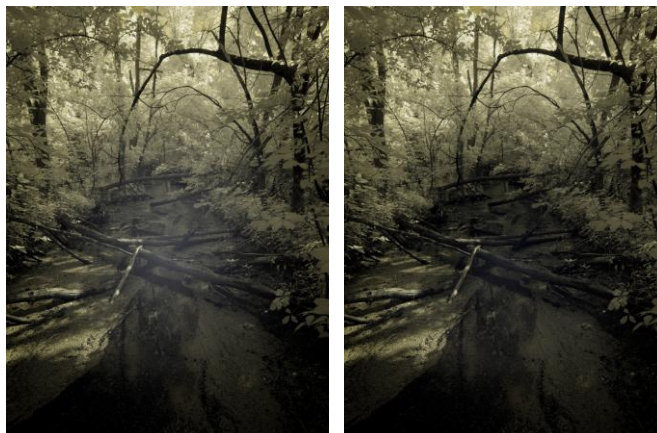
When you take IR photographs, you may notice a circular area of flare light in the center of the frame commonly known as a hot spot. Hot spots are mostly caused by internal reflections within the lens – while most lenses eliminate such reflections in the visible light range, they may not do as well for IR. Thankfully, manufacturers seem to be catching on to this problem and many recently released lenses have fewer problems with hot spots.

Hot spots are more likely to be a problem with wide angle lenses, especially when shooting into the sun, but they can also vary unpredictably in radius and intensity from lens to lens and with focal length and aperture. There are several web sites that list different lenses and evaluate their tendency for hot spots (see the Appendix for more information).

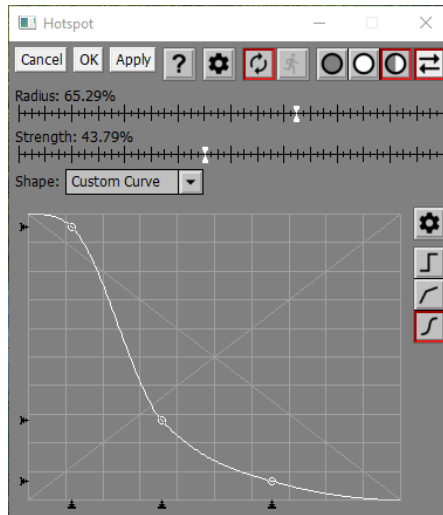
Sometimes the hot spot is stronger in one color channel than the others, depending mostly on the white balance.

If you are trying to create an IR panorama by stitching together multiple images, make sure to remove the hot spots from each image before stitching them, otherwise you will get multiple hot spots in the panorama which are subsequently much harder to remove.

Here is an example of an unusually bad hot spot that resulted from using a particular wide angle lens and camera combination I have since learned to avoid. With most other lenses, central hot spots are far less obvious. Next to the hot spot version is a corrected version made using Picture Window's Hotspot transformation.

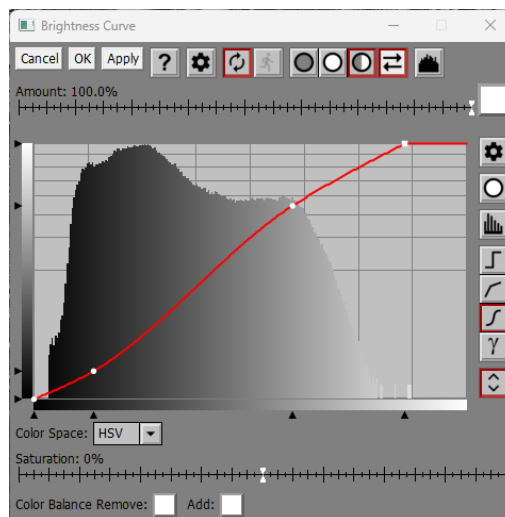


Hot spot removal is performed by modeling and then subtracting the flare light from the image. Picture Window assumes a standard profile for hot spots given their center and radius. While this works well most of the time, you may have trouble removing some stubborn hot spots completely if they have an unusual profile. In this case, you can create a custom curve that models the way the flare light falls off with distance from the center of the hot spot:



## Stretching the Dynamic Range

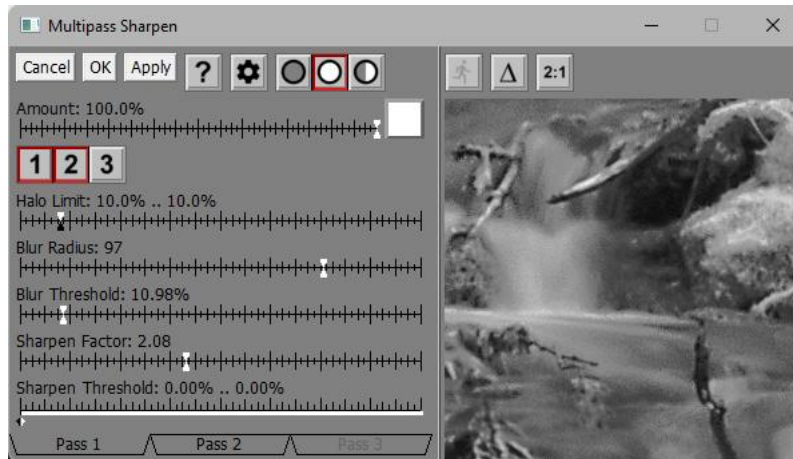
Due to the lower dynamic range and contrast of most IR images, the original tonal range frequently does not run all the way from pure black to pure white and the contrast is low, making the image look dull. This can be corrected using a Brightness Curve transformation.










## Increasing Local Contrast

Something else that can be effective on IR images is local contrast enhancement. This can be done using the Multipass Sharpen transformation (Transformation/Sharpen/Multipass):



## Putting It All Together

Since I run almost every IR photo through the same set of transformations, I created a snippet to record all the steps so they can be applied to other images. This is just a starting point since the finished image may need some touch-up cloning or speck removal, some dodging and burning and perhaps some final cropping.

	Open the camera file (DNG or converted TIFF file)
	Convert from 48-bit color to 16-bit black and white
	Remove the central hot spot
	Stretch the dynamic range and boost contrast
	Local contrast enhancement

## Nature and Landscape Composition Tips

Composing landscape photos is difficult to begin with, but IR landscapes pose additional challenges. Like other forms of black and white photography, light, contrast, shape and texture are very important. For example, scenes that contain only evenly lit foliage or flowers will render as mostly white. The novelty of this “it looks just like snow” effect wears off quickly, but don’t give up on IR at this point as many other opportunities develop if you keep experimenting.

### Previsualization

Previsualizing IR is tricky – often the results are surprisingly different from what you expect. The best way to previsualize IR is to look through the camera viewfinder, even though you may have to post-process the image quite a bit to get your final image. I often carry around a small point and shoot camera converted to IR to preview compositions before setting up my tripod and main camera.

### Sunny or Cloudy – Which is Better?

Some photographers recommend shooting IR mainly in full sun, however I have found that, similar to visible light photography, cloudy or overcast skies usually produce more interesting results. Soft light can help bring out subtle details and textures and avoid harsh shadows and pitch black skies. The conditions that work best for you will naturally depend on your photographic style. Here is an example of the same location photographed twice, about one year apart – once in full sun and the other with heavy cloud cover:



Even if the skies are clear, you can still get very nice images shooting during the blue hour before sunrise such as the example below or after sunset.





## Generating Contrast

Contrast between light and dark is an important ingredient in many good black and white landscape compositions. There are many ways to generate contrast in IR photography. Here are some techniques you can use to generate contrast in your images.

### Living/Non-living

Since foliage tends to absorb visible and reflect IR light, foliage, grass, moss and other vegetation show up lighter while inanimate objects such as rocks, water, dirt, tree bark and buildings usually show up darker. Even dead or dying vegetation continues to reflect IR so dead leaves and fall foliage still show up light.



Not all foliage is the same – for example mosses and evergreens usually appear darker than deciduous trees or other leafy plants, presumably since they reflect less IR light.



## **Sky/Clouds**

Clear, blue skies tend to show up dark or black in IR. Clouds reflect IR light and therefore show up light. You can use this type of contrast to create very dramatic skies.





## Light/Shadow

As with visible light photography, areas of a scene receiving direct sunlight show up brighter than areas in shadow. This type of contrast can work well in dappled light.



## Water

Streams and waterfalls are often rendered somewhat darker in IR than in visible light, making them recede into the background. Therefore, it often improves the image if you selectively lighten these subjects.



On the other hand, still water often appears very dark or black which can produce striking contrast with floating vegetation.



## Resources

Here are some links to various products, information and services mentioned in this document.

### Camera Conversion Services

By searching the web, you can find a number of IR or monochrome conversion services – check the reviews and prices and make sure your camera is supported before sending it in. Of the following, **LifePixel** is easily the largest and offers the fastest service.

\* [LifePixel](#)

\* [Kolari Vision](#)

\* [Monochrome Imaging](#) (monochrome conversions, especially for Sony cameras)

### Clip-in IR Filters (that mount behind the lens)

\* [STC](#)

\* [Kase](#)

\* [Kolari](#)

### External IR Filters (that mount on the front of the lens)

\* [Kase](#)

\* [Kolari](#)

\* [LifePixel](#)

### Monochrome RAW File Converters

\* [Monochrome2Dng](#)

### Lens Hot Spot Databases

[Kolari](#)

[Edward Noble](#)

[Blue Sky](#)

[Photonius](#)

\* Products or services I have used and personally recommend