

The Power of Near Infrared Photography

By Tracy Rose
Aquiline Photography of
Colorado Springs, Colorado

Aquiline Photography 2014 ~

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**Blemishes and even freckles often do not show up in NIR
(I like the freckled version too)**

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Intended Audience

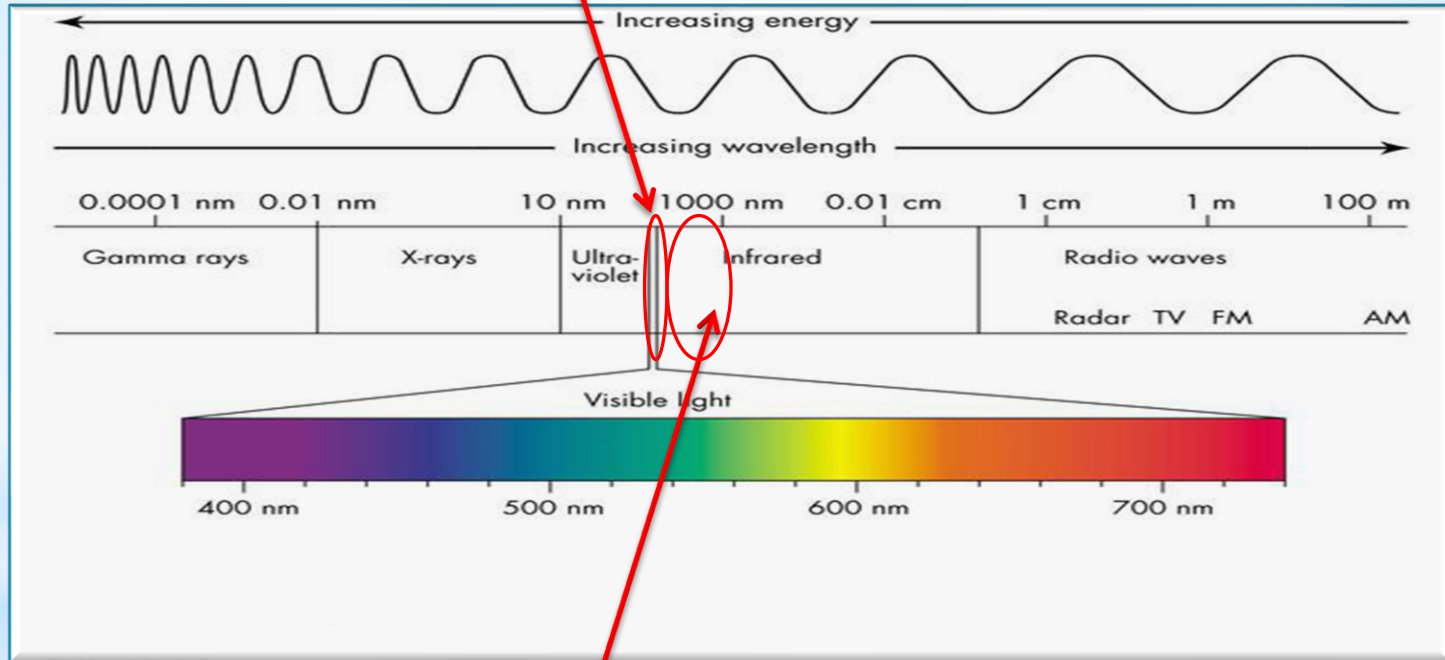
I am personally drawn to the near infrared because of its unique and sometimes inexplicable beauty. These slides are for photographers that are interested in something beyond traditional photography

Who else may like NIR photography?

- Photographers interested in near infrared but ready to advance beyond fine-art black/white, public parks, and cemetery images
- General folks interested in the near infrared and the future of everyday images seeing people in near infrared
- People who like an artful & edgier vampiric look to people's appearance

It might help to visualize below where near infrared occurs in the spectrum...

Humans see from 400 and 700 nanometers wavelength



Near infrared is at 700 nanometers to 1400 nanometers wavelength

- A nanometer is a measurement for one billionth of a meter used in the spectral sciences. Since commercial cameras drop off abilities to detect at 1000 nanometers this is sometimes determined as the end of near infrared

NIR Photography FAQ

- People often ask if the AQ (Aquiline) camera is converted or uses a temporary filter. The AQ camera hardware is converted permanently and to only pure near infrared (passing no visible spectrum). Both methods work but the temporary filter method requires a longer period to expose an image
- In an infrared conversion they take out the glass that sees visible light and install glass that only passes near infrared light (beyond human vision). Replacing the hot-mirror as they call it changes the entire camera outlook
- Other glass types exist too. These other glasses create cameras with near infrared mixed in different ranges. Some pass visible light and near infrared together for a more full spectrum effect. There are many variations in glass that can affect the final infrared image



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The Byodo-In temple in Hawaii shown in near infrared.

Aquiline Photography of Colorado Springs, Colorado ©

NIR Photography Clichés

- New infrared photographers often get odd tones or red looking images. However, by putting the camera on program, manual, or other creative modes and using a healthy plant as the “custom white balance” , one can see marked improvements
- Photographer’s first projects often involve cemeteries in near infrared. This is because cemeteries are often well watered, well manicured, and have headstones that show terrific contrast from the vegetation
- Taking pictures of glass, steel, and stones often look the same as black and white film photography. However, foliage takes on a snow white winter look
- Many times the red and blue channels of an infrared image are swapped in post production to make the sky blue and more acceptable to common audiences



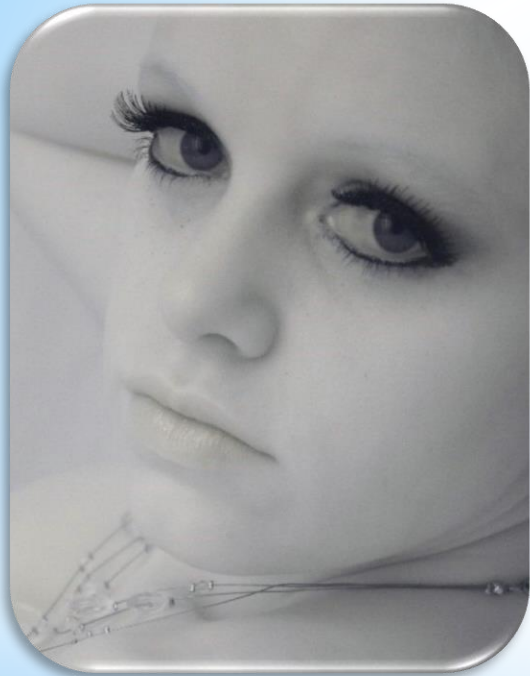
Aquiline Photography 2012

Artsy image taken at a cemetery in near infrared

Aquiline Photography of Colorado Springs, Colorado ©

Unflattering Eye Appearance in NIR

- The portion of the eye normally white as we know it, appears gray in the NIR. This could be one reason our photographic ancestors remained with far off photographs of models such as in fine art
- The skin on the inner eye nearest to the bridge of the nose, appears dark on many subjects. This is particularly true with light skinned models. Since glamour shots often airbrush away the bags under eyes, blemishes and sometimes scars, it is not that difficult to airbrush out the “black eyes” as they appear in the NIR image
- Contact lenses often appear very bright and well defined. This can give the eyes in NIR a demonic like appearance. For art images this can be fantastic



Whites of eyes appear gray



Inner-eye appears dark



Contact lenses make eyes appear more defined



Human Eye Appearance in NIR

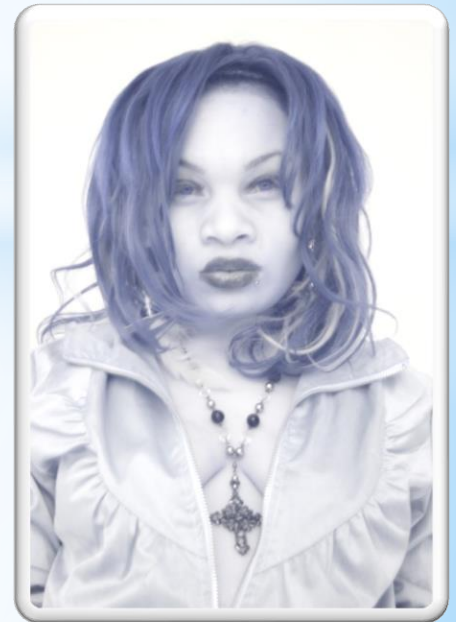
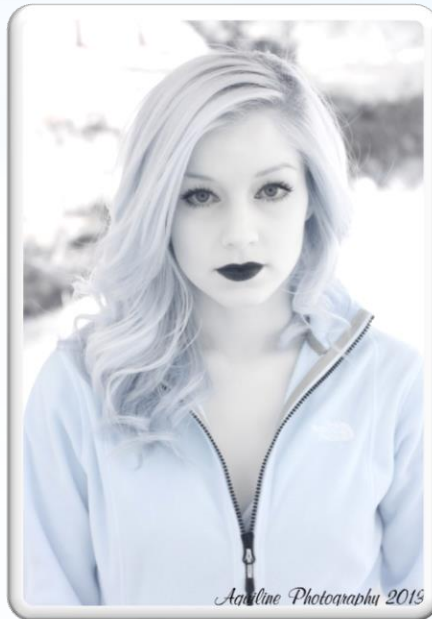
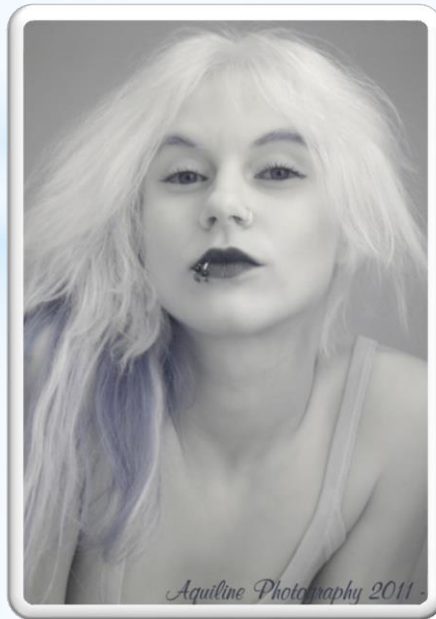
Lipstick Appearance in NIR

- Lips without makeup blend into the rest of the face in NIR. This makes it harder to see expressions we might normally enjoy. Red lipstick specifically vanishes in the NIR causing the same often washed out appearance of the lips as no lipstick at all.
- If black powdered makeup is mixed with red lipstick, a quick makeshift black lipstick can be created on-scene for the near infrared photo-shoot contrast. With a ratio of black one could fade the lipstick into the shot as desired
- Jet black lipstick shows up wonderfully in NIR but does have Gothic looking overtones

Model wearing **red** lipstick



Black lipstick shows
in near infrared



Dark Makeup Remains Dark in NIR

- Dark makeup remains dark in the near infrared. For this reason when darker skin models pose for NIR they must fade their makeup evenly.
- Touchup makeup on dark skinned models can appear as splotchy skin for the same reason
- If desired one could use the darker makeup for a face paint design that would only show up in the NIR



Visible Image

Near Infrared

Dark Makeup Remains Dark in NIR

Aquiline Photography of Colorado Springs, Colorado ©

Clothing Thread in NIR

- Thread can be made of many materials depending on what is sewn.
- Sometimes thread appears brighter and easy to see when it was perfectly matching in the visible (notice the leather jacket in the illustration)
- Similarly, the undergarments in the illustration were black as was the thread. In the NIR the thread remains black while the laced bottoms look much brighter than visible.
- Seeing dark thread can cause one to think they are seeing through the underwear when they are not. Most of the time panties and other undergarments have threads sewn in such a way that the view does not reveal female private parts

Near Infrared

Visible Image



Threads Appear Bright in NIR



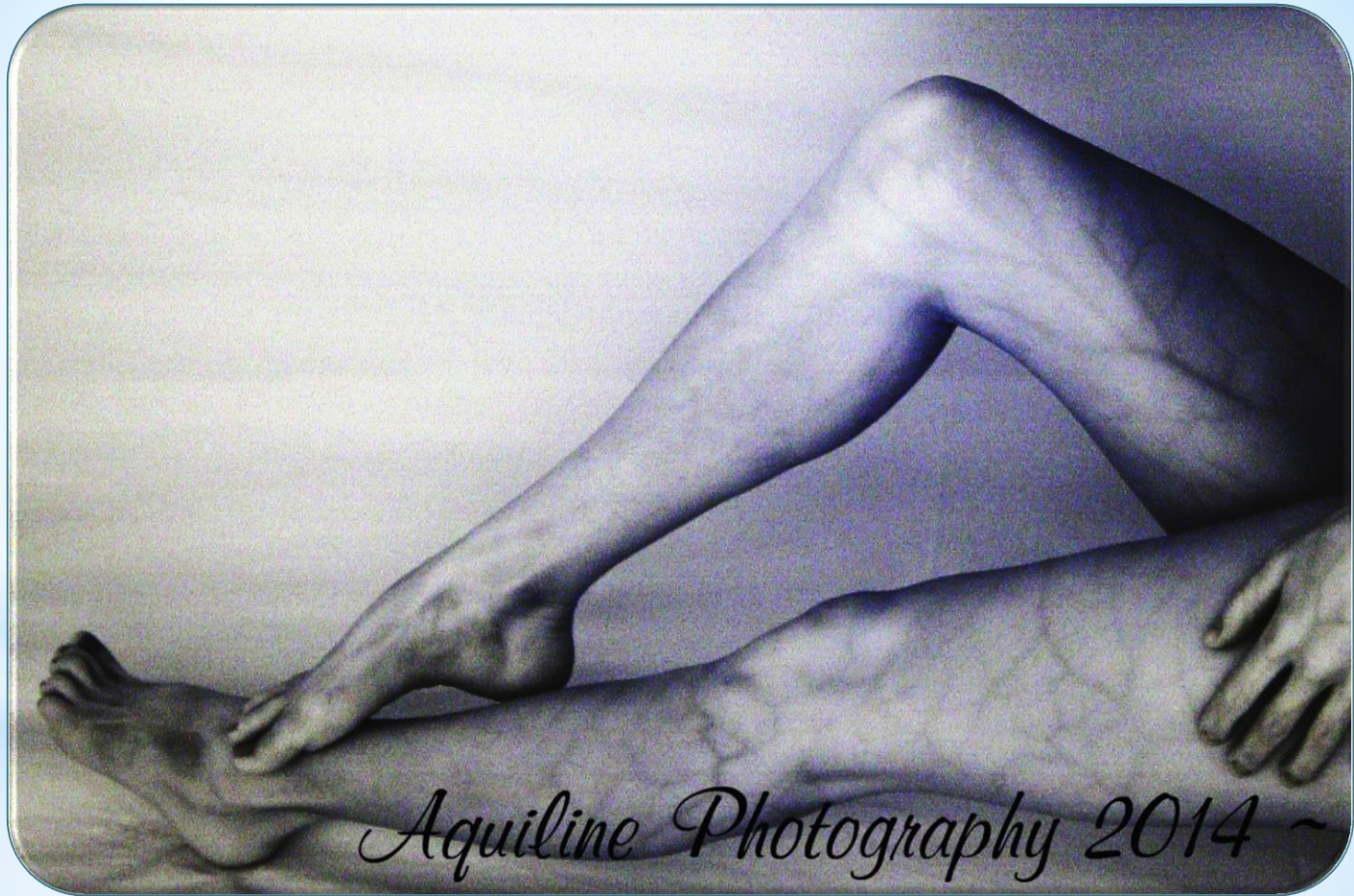
Threads Appear Dark in NIR

Clothing Thread in NIR

Aquiline Photography of Colorado Springs, Colorado ©

Skin Penetration

- NIR penetrates the skin millimeters deep and gets absorbed by hemoglobin in veins. Then it bounces off regular tissue. Because of this some medical machines use it to measure oxygen levels in the human body. Many areas of the medical field take advantage of the NIR's ability to penetrate tissue with its long and soft waveform
- Photographically performing an “**equalization**” on the image helps contrast human veins when doing photography. Equalization means when a computer program equalizes all the color channels in an open image during post production
- Veins show up easily in the NIR. Therefore one can see early signs of some medical problems or simply be completely fascinated by the ghoulish appearance of the image



**A blonde fit model displays veins in the NIR
not visible to the eye normally**

Aquiline Photography of Colorado Springs, Colorado ©

Skin Penetration

- Some infrared sites have claimed breast tumors, acute abdomen, thyroid gland, burn severity, and even limb disease are being assisted medically by NIR.
 - Reading too much into NIR results without medical knowledge is probably unwise. For instance, facial makeup can cause the skin to appear splotchy if applied unevenly on dark skin and could alarm the photographer in NIR but not be seen by normal vision. This would not be a medical issue
 - Tattoos contrast very nicely due to the skin penetration of the NIR. Often on darker skinned subjects, tattoos that were hardly visible become incredibly clear and marvelous looking
- * Fun fact, movie studios have asked for AQ consultations on how to maximize the vein effects for zombie characters if they filmed in the NIR



Tattoos gain wonderful contrast in NIR

Aquiline Photography of Colorado Springs, Colorado ©

Skin Demographics

- Older tattoos can often be recognized because the NIR shows slight ink bleed under the skin compared with more crisp edges of new tattoos
- Many people believe near infrared looks like black & white traditional imagery. However, it is very different to the experienced eye
- Red-heads and blondes seem to be the most skin penetrating and show the considerable veins and contrasting features. Their often pale skin looks very vampire-like in near infrared. Very dark skin subjects appear light as well but not always as vein displaying
- Consider how dark skin appears in the provided grid image example. Here infrared gives a very light skinned return and can be discerned even within mixed up tiles of infrared , non-infrared, and color

Near infrared



Gray scale
Traditional image

**Dark skin looks light in the NIR
with these simultaneously taken images**

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Skin Demographics in SWIR

- Near infrared makes everyone appear somewhat “white”. However, there are other portions of the imaging spectrum that hint at doing the opposite.
- Consider InGaAs sensors in SWIR or short wave infrared. This range of infrared hints at light skin people looking very dark-skinned and hair color inverting to appear pure white
- Most SWIR technologies are not yet available to the average photographer. SWIR technology does allow imaging to see deeply into smoke-filled fire areas. This said, you will be hearing much more about this type imagery in the future and how it helps fire fighters
- Near infrared glows anything water-retaining such as plants, skin, and clouds. SWIR imagery on the other hand seems to darken water retaining eyes into black marbles, darken skin and so forth. Conversely dryer materials such as hair on the head and eyebrows glow pure white in this SWIR range



**InGaAs sensor in SWIR or short wave infrared
makes even light skin people appear dark**

(Image from video on YouTube by NewImagingTechnoNIT
https://www.youtube.com/watch?v=_qXqjWa5z68)

Vegetation Glows!

- NIR makes vegetation glow. This is one of its most memorable features. The more healthy the vegetation, the more it glows and vice versa. Usually this means how much water the plant retains
- When trees are physically stressed or wounded due to insect damage this shows as less bright vegetation. Farming practices use NIR to determine crop health
- The military uses plant health because cutting down a tree for camouflage means the wounded tree would show different tones and the target underneath would be detected



**The year around trees are often darker
than broad leaf trees in near infrared**

Aquiline Photography of Colorado Springs, Colorado ©



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**With the naked eye this dark rabbit
in dark vegetation shadow was difficult to see.**

Aquiline Photography of Colorado Springs, Colorado ©

Vegetation Glows!

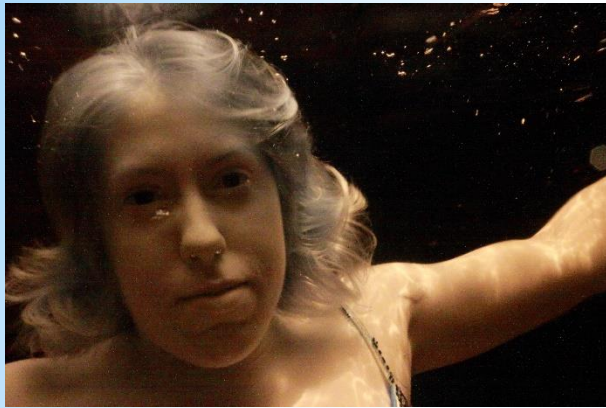
- Multiple bounces of NIR light occurs when one is under tree canopy. NIR can bounce from tree to tree as though each healthy leaf were a mirror of light. So counter intuitively , for photography the places that are more foliage shadowed become even brighter! One may have to turn down their exposure levels because of this
- Year-around trees such as pine trees (called coniferous) are more subdued or darker than broad leaf trees (called deciduous) quite often in NIR. The coniferous trees are accustomed to making it through the winter with less water and can be distinguished in NIR as a bit darker
- In the illustration, if a rabbit hides in dark green trees in the shade, the NIR would show him in contrast and he would be found quickly

Water Absorption

Near Infrared get absorbed by water. The water in the scene below is crystal clear.

The exceptions seem to be when water is inside the cells of skin, inside the cells of leaves, or cell-like pockets of clouds that are not filled with pending rain.





Due to water absorbing near infrared, images taken under clear pool of water appear dark



Aquiline Photography of Colorado Springs, Colorado ©

NDVI Algorithm

NDVI stands for Normalized Difference Vegetation Index

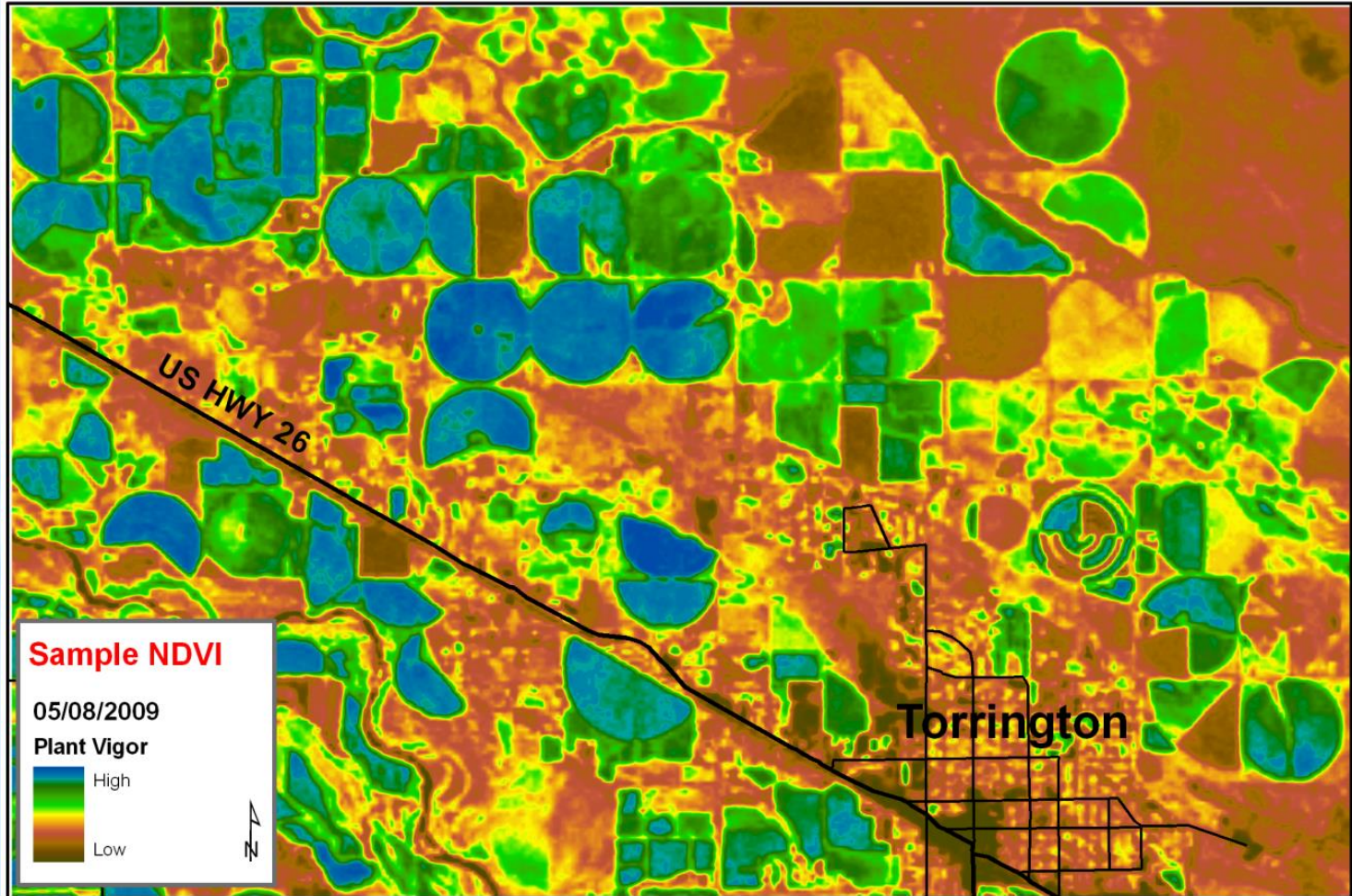
Fundamentally, NDVI is assigning different colors to an image where values come from the amount of photosynthesis. Areas of high photosynthesis or supposedly healthier plants are assigned cooler colors, and areas of low photosynthesis are assigned warm colors. It is thus a way to determine which areas of a field have the greatest and least water or vegetative abundance. The NDVI image must be made by doing math with an image that has both near-infrared bands and standard red, green, blue channels.

As you recall from earlier, healthy plants appear bright in near-infrared and they do not appear bright in a standard red of the imagery with RGB channel. By dividing the RED band by the NIR band one could get the visual of healthy plants. The NDVI takes it a step further math-wise for better results in the formula below. By performing some simple math, one can create a visual of the ratio of healthy vegetation and color-code it.

Most hobby cameras cannot perform this algorithm because their red, green, and blue channels are all filled with near infrared images in all three channels if hardware is modified. The same is true with filter created near-infrared images. Usually satellites have a red, green, blue, and near-infrared at bare minimum.

$$\text{NDVI} = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}$$

NDVI Product



Material Distinguishing Applications

- Materials that often look the same but are not the same, are distinguished as different in the NIR view. Differences in paint for example, that cannot be discerned with normal eye-sight are quickly distinguished
- Dyes in clothing can look very dark in normal vision but appear very bright and reflecting light in NIR
- Conversely, many color patterns are blended together in near infrared but not visible light. A busy pattern on a floor rug in a hotel for instance, may look quite garish to hide stains. If the near infrared blends it all together the vivid colored rug may look much more pleasing in near infrared than visible imagery



Colorful hotel carpet



Colors in carpet pattern look similar in NIR for a less busy appearance



Replacement bumper looks different in the NIR



Original paint in NIR

Original Hair Tone Detection

- Blonde hair even when dyed raven black will show light toned in the NIR.
- In NIR dark hair will be dark toned, blonde hair will often be mid-toned, and bleach blonde will often be very bright and reflective
- Note that if the hair has been dyed it will appear more bright in NIR due to how the dye makes NIR light reflect



On top the subject is normally blonde while
the subject below is normally dark haired
NIR can distinguish the difference

Aquiline Photography of Colorado Springs, Colorado ©

Iron Appearance in NIR

- Iron absorbs near infrared. Iron fences, rails, and other iron objects appear very dark in near infrared
- Reddish rust looking dirt will also give darker tones by containing iron and other minerals
- Most metals appear gray or silver-gray in NIR. In this way, infrared is usually absorbed by metal materials to some extent and can be predicted as the darker element in costumes, jewelry, and fashion accessories



Iron such as fencing and rails, absorbs infrared light and therefore appear dark

Aquiline Photography of Colorado Springs, Colorado ©



**Most cotton-based fabrics reflect near infrared.
These fabrics appear bright in the NIR view when
they are black in the conventional view**

Aquiline Photography of Colorado Springs, Colorado ©

Clear Sky Appearance in NIR



NIR waves get absorbed into water and never return for lakes and rivers. Similarly, NIR light heading into the moist atmosphere does not bounce back leaving a dark sky.

Aquiline Photography of Colorado Springs, Colorado ©

Sky in NIR

- NIR waves are large waves compared to the blue light waves. They head into the moisture holding atmosphere and get absorbed by the sky.
- Water reflects NIR in the leaves of trees or human skin as shown before. Both leaves and skin have cells that act as a sort of house-of-mirrors. So even though skin and leaves have moisture they reflect back the NIR and don't turn black as rivers and lakes do. Since clouds are moisture and yet often appear white, perhaps it can be assumed they create pockets of air much like the cells of skin and leaves?
- NIR does badly in a stormy day outside. Clouds that used to appear white are now mostly water. Most all of the infrared energy we receive is generated from the sun. So these images can be quite dark!
- On a day that is overcast with clouds, it may appear quite dark in the infrared camera. On a mildly cloudy day turning the exposure all the way up may be necessary

Stormy Sky Appearance in NIR



Cloudy days can appear darker in NIR than is visible to the eye
due to clouds blocking the sun's NIR light

NIR Lights only

(a scene with predominantly only NIR light)

- NIR light is often generated and viewed from security cameras. These can give off NIR light after dark. This allows the security cameras to view the scene but the surroundings appear dark to an intruder or burglar since solely NIR light is present
- Celestial objects can give off NIR while not giving off much conventional light. This means astronomy experts can gather more information with NIR sensors regarding space events and objects. Additionally dusty space regions image well where large waves of NIR give a clearer picture than conventional imagery
- NIR specific lights are used by manufacturing. They shine on products on assembly lines showing defects, spoiled foods, or other quality control aspects in products assuring problems are more readily detected
- Products exist where a gun with an NIR laser can determine the material point at and display the results immediately. This allows miners and other geologist to know the exactly minerals that the non-destructive light shines upon from the calibrated sensor.



Television remote controls often disperse NIR light to change channels. Viewed in infrared these remotes appear more like a flash light



Friendly feral cats are monitored at night. Seen here, they share food with a skunk in NIR Light only on security camera view

Long-Range Reflectivity

(In night time scenes)

- At night one can often see what looks like small lights in the distance across the street through an infrared security camera. The next day it turns out to be just a chrome bumper or mirrored surface. The amazing part is that the light coming off the security camera didn't even extend say ten feet in the property but the shining of the object might be a hundred feet or more.
- One of the almost humorous 'spy' kits they sell on Amazon.com had an infrared plastic eye piece, where you were instructed to turn on a tv-like remote light and look through the eye piece. If there was a secret camera in the room then the lens of that camera would appear in near infrared according to the instructions. While being laughable at first this technology does have some merit.
- Compare a true-color image and how it may only light up 10 feet (if it were night with a porch-light for instance). However, with infrared the headlight's mirrored casing is now observed hundreds of feet away in pitch dark. It acts as you would expect holding a flashlight in true color and waving it around at night with a directional beam. Although IR is much longer waveform, why the exaggerated reflectivity?



Automobile in daylight



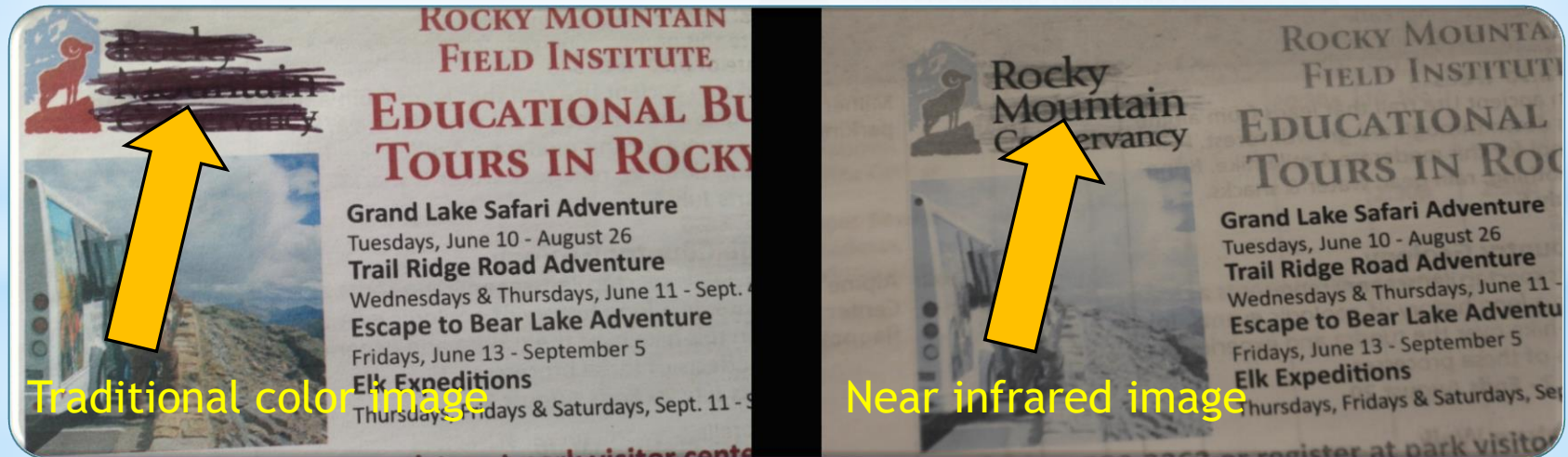
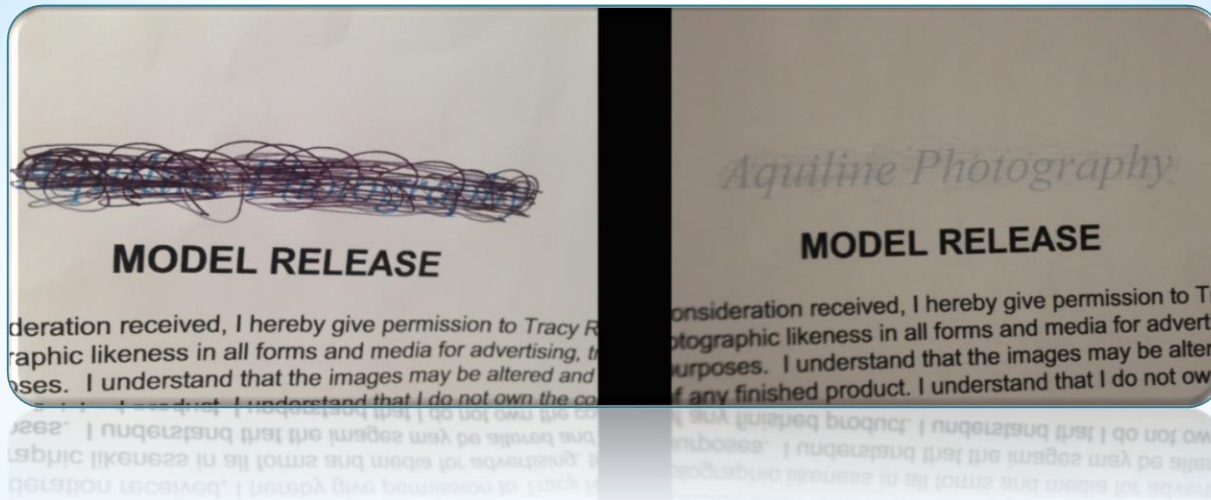
Reflective surface in near-infrared



Day and night combined to show source of reflectivity

Forensics & Ink Penetration

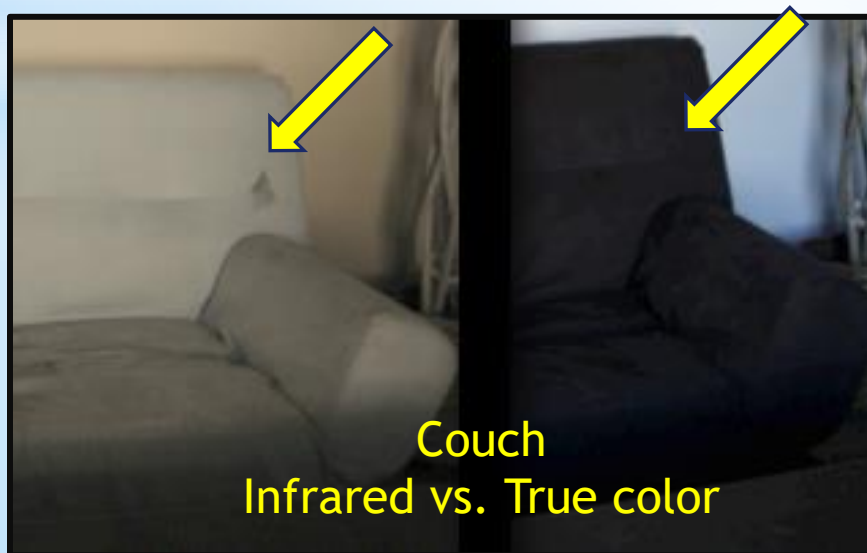
- NIR makes common ink from a writing pen almost completely transparent. This can allow someone to read hidden notes even after the paper is scribbled upon by pen.
- Note that black markers such as Sharpie pens are not transparent to NIR and remain dark in visible and near infrared
- If a different ink was used to alter or update a document it is often possible to see the difference in NIR due to the ink difference. For instance, if a bank-check was alter by a different ink but looked the same with normal vision



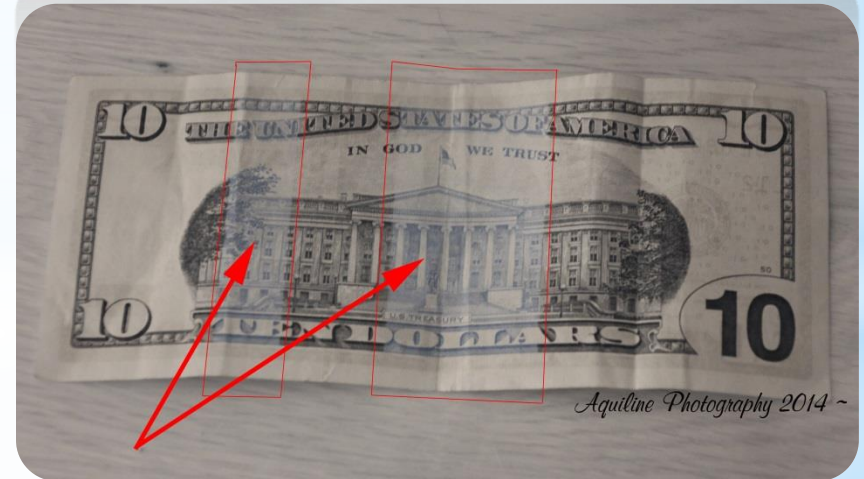
Simultaneously taken image pairs show ink from a writing pen is fairly transparent in NIR

Forensics

- NIR banding put on currency by the United States government allows someone to determine counterfeits if they can view the bills in infrared
- The material-distinguishing abilities and other properties make infrared a probable forensics tool as well. For instance, seeing dirt or blood stains on a solid black piece of furniture or carpet but the furniture appears white in NIR. Revealing the stains could be helpful



**Using the material
distinguishing abilities for
forensic purposes**



The Government has put banding on U.S. currency that is only visible in the NIR

NIR & Heat Detection



**Extremely hot objects show up well in infrared
more obvious than traditional vision**

Aquiline Photography of Colorado Springs, Colorado ©



Infrared

True Color

**Hot spots of the forest fire appear in near infrared
but are not seen with the naked eye**



True Color



Infrared

The NIR appears to have some if only very superficial abilities to see through smoke regions (some trees in front row are more viewable)



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**The Colorado Springs mountains
burn during the 2012 wildfire disasters**

Aquiline Photography of Colorado Springs, Colorado ©

Macro Photography and Near Infrared

- Near infrared brings the ability to penetrate materials to macro photography. The armored shells of insects can sometimes appear translucent to add even more alien-world to this small perspective
- Most science based studies of insects with near infrared often measures the absorption of light by organic molecules
- Near infrared has been used in spectroscopy to detect insect infestations and even certain infections within insects



Praying mantis in near infrared

Courtesy of Photographer Chris Dorschutz

Aquiline Photography of Colorado Springs, Colorado ©



A color swap, dynamic range composite, and saturated colors created this artistic infrared shot

Aquiline Photography of Colorado Springs, Colorado ©

Art

- Art has benefitted from near infrared by allowing a different view of our well known world. Some glamour model images appear even more interesting than body-paint for instance without any additional supplies or effort
- Art paintings have been discovered to have other paintings or crude drawings underneath them via near infrared imaging. This greatly gives more understanding of the artist's intentions with certain works or modifications done that weren't previously known
- One cannot see in near infrared but the artistic scene can be visualized. The scene can often not be fully composed until an NIR image is actually taken. Then and only then are those subtle nuances of the invisible world of near infrared seen



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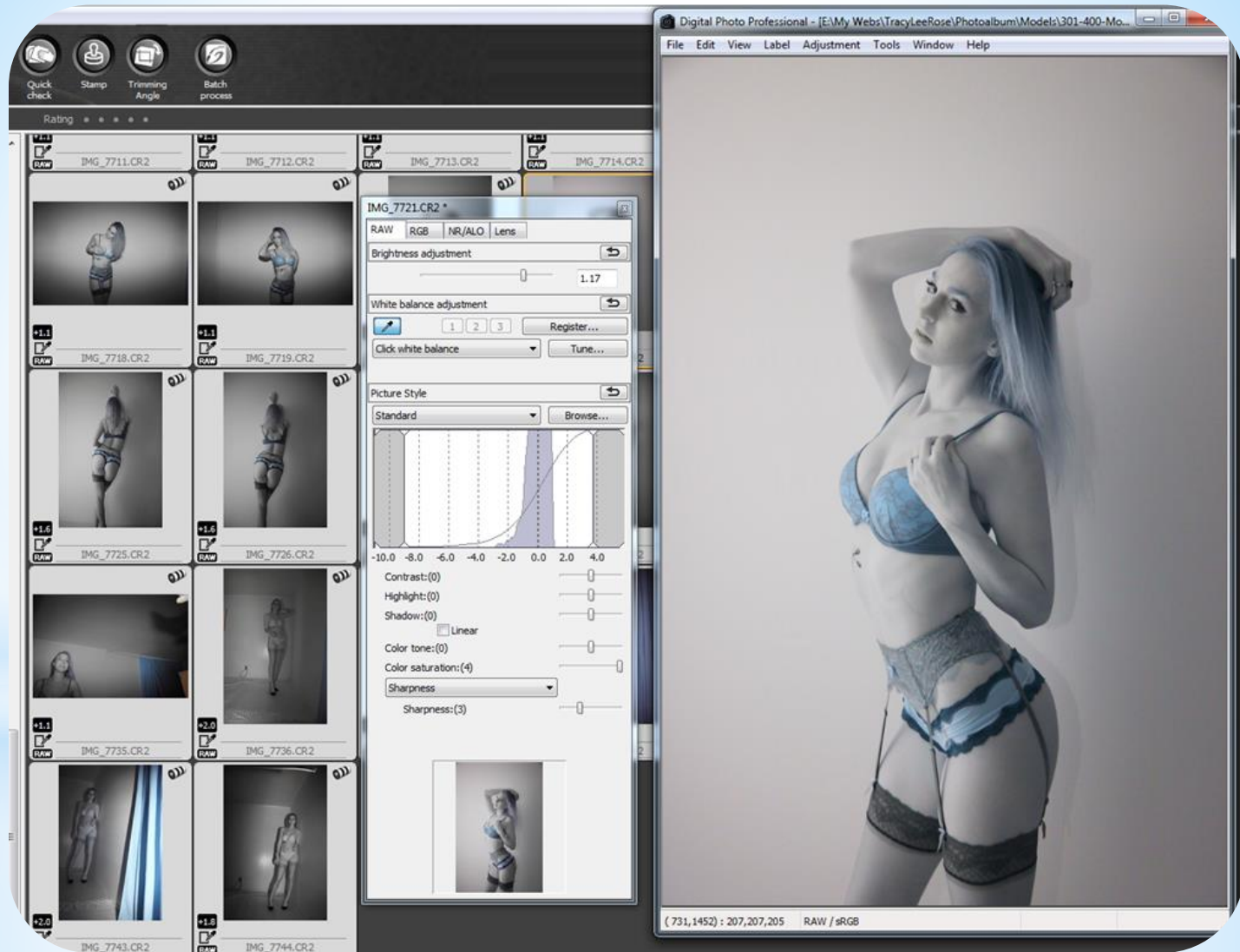
**One of the artful properties of NIR is that
Images take on an other worldly look**

Aquiline Photography of Colorado Springs, Colorado ©

RAW Images & Color Saturation

Lastly, NIR's almost black and white imagery can win you over artistically. As an artist they teach you to turn your image upside down. Now what do you think of it? Flip it horizontally and learn how unexpected your symmetry suddenly looks. Turn it black and white and textures and intensities get your attention that you never considered.

The point is near infrared gives this but with that extra magic. By magic one can think of the few colors left in the pure infrared and almost selective color-looking in blue created by synthetic fabrics and dark hair. One may love the subtle blue but why keep it subtle? You must shoot in raw imagery to use the raw software. In this way there is no need to keep white balancing for near infrared and that's a time saver. The photographer has the ability to crank the saturation up in raw software without distorting other parts of the imagery as you would in a final jpeg. This works amazingly even more regarding indoor-studios and using flash for bringing out the best colors in near infrared.



RAW Imagery & Saturating Colors

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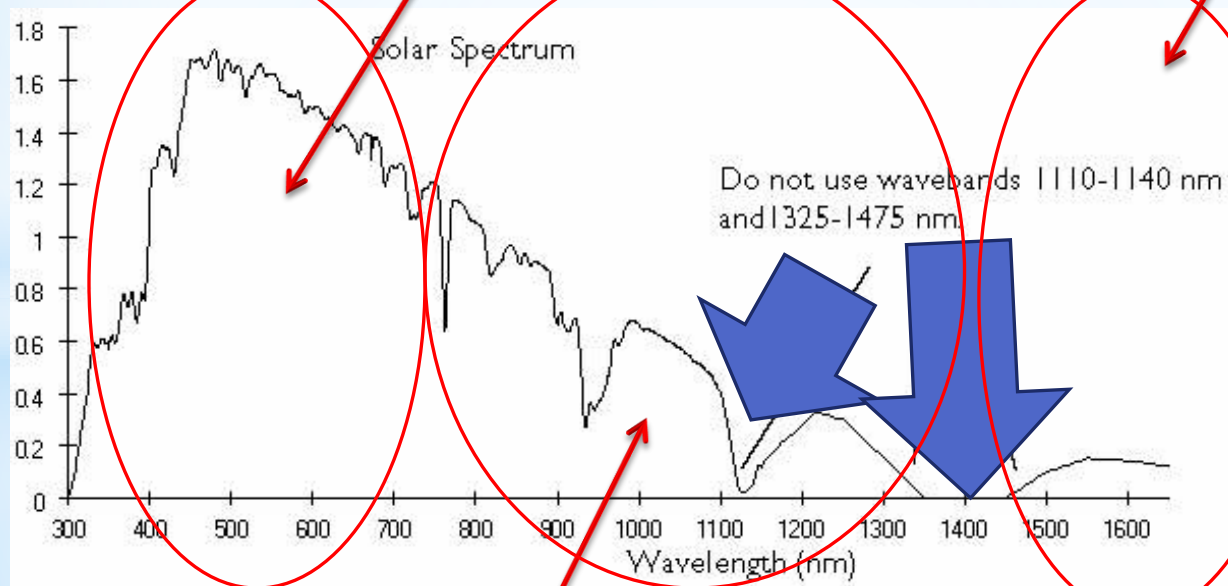
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End any questions?

Humans see from 400 to 700 nanometers wavelength

SWIR 1,530-1,560 nm



Near infrared is at 700 nanometers to 1400 nanometers wavelength

Thermal infrared 3-14 μm

* A nanometer is a measurement for one billionth of a meter used in the spectral sciences.