Buying a Home Microscope

The process of ecological restoration requires many tools. I initially learned about prescribed burns, pumper units, backpack sprayers, and Parsnip Predators. But there are 2 other tools that I've found important in my quest to learn more about all aspects of ecological restoration, a camera and a microscope!

I imagine my journey through restoring prairies, savannas, woodlands, and wetlands began in about the same as many others…learning about the plants and learning techniques for managing the plants. I dove into this head first! I began taking photos of every aspect of the plants that I could. I wanted photos of stems, leaves, petals, stamens, sepals, and seeds. I wanted photos of each plant through their growth stages from seedlings, to vegetation, to flowering, to senescence. The more photos I took and the more I learned, the bigger the picture of the restoration became. I realized there were many aspects working together to make this restoration successful. There was the soil and its ecosystem and processes and there were the insects, the birds, the mammals, the reptiles, the amphibians, and the fungi to consider. The biggest question that niggled at me was how could I possibly create a management plan when the only aspect of the land I knew about were the plants. Well, I also knew a great deal about the birds and their relationship to the plants, but I needed to know much more. I began studying the other aspects!! And once I was through the mammals, reptiles, and amphibians, the subjects started getting smaller and smaller and smaller. I needed a microscope.

My background and education is in business not science. I had only worked with student microscopes in high school, you know, the ones that crush the slide as you get try to get the specimen larger and larger? I quickly realized that I had another learning curve to scale! I'd like to share the

knowledge I gained with the hopes that others will be able to spend their time learning about the micro ”things” that interest them and not so much on the purchase process.

A microscope in its most basic form is just a single objective lens, such as a magnifying glass. The objective lens collects light and provides some minimal magnification. A compound microscope adds a tube and an eyepiece lens to allow for higher magnification and correction of problems that are prone to simple lenses. A focusing mechanism allows for moving the eyepiece relative to the objective lens as the objective is moved relative to the subject. Two compound microscopes working together make a simple stereo microscope which provides some depth perception.

A simple lens is a piece of glass with one or both sides ground to a curve and polished. A simple lens does not create a perfect image because it is prone to problems, or aberrations, such as separating colors or not being able to focus subjects near the edge of the lens. A compound lens is one where multiple simple lenses have been glued together to correct for aberrations. Most modern optical instruments such as microscopes, telescopes, binoculars and even loupes use compound lenses for better performance.

Because my interest is mainly in 3D objects, I chose the stereo microscope. Whew! One decision down! Now for the multitudes of other decisions and questions. I knew I didn’t want the student version nor did I want to go to the other end of the scale and spend $10,000. I was glad to find that there are many microscope options and prices in between that range. I began weeding through all the possibilities and learning what was important, what was not, and what could be ascertained from the specifications of the scope and what couldn’t.

All of the mid-range microscopes are Chinese-made. The best of the Chinese microscopes are very good, both optically and

mechanically. Unfortunately, Chinese factories also produce inferior microscopes and it's impossible to tell the difference just by looking at the scopes or comparing prices. The best way to get a good one is to buy from a reputable dealer. If you don't have a referral from someone you know then ask lots and lots of questions. Here's a crash course in microscopes so you'll know what questions you want answered.

There are 2 types of Stereo Zoom Microscopes; the Greenough-type and the Common Main Objective (CMO) once called cycloptic.

The Greenough-type are stereo zoom microscopes that create the image using optics for two compound microscopes side by side. These microscopes are inexpensive, simple to use, and easy to maintain. The zoom means they move on a continuum within their minimum and maximum magnification.

CMO microscopes use a single large objective that is shared by 2 eyepieces. These are those very expensive microscopes that are produced by the "Big Four" – Olympus, Nikon, Leica, and Zeiss.

Both Greenough and CMO stereo microscopes have their advantages and the choice between them is usually based on the application rather than whether one design is superior to the other. However, a major consideration is cost. CMO stereo microscopes can cost several times more than a Greenough stereo microscope, so this will naturally influence buying decisions. On paper, the CMO would appear to be the superior microscope, but you really can't base your decision on paper specifications. Why? Because, on paper, some microscopes look great, but if you're wanting to go the next step and take photos with your 'scope, you need to dig further.

There are 5 main items to consider when purchasing a microscope:

1. Magnification

2. Resolution
3. Optical Quality
4. Comfort
5. Illumination

Magnification

Stereo microscope magnifications are typically between 20x and 80x. Viewing of live specimens, such as insects, is best at the 60x to 120x total magnification range. Magnification has 3 main aspects to consider: 1) objective lens, 2)zoom ratio, and 3) field of view.

The objective lens is the one closest to your specimen and provides the initial magnification. The amount of magnification is related to the focal length of the lens (the distance from the lens to where the light gathered by the lens comes into focus) and the distance to the subject. In microscopy, short subject distances mean the shorter the focal length the higher the magnification. In Greenough systems, the objective lens magnification is 1x unless otherwise specified.

Eyepiece lenses multiply the magnification provided by the objective lens. If the objective is 2x and the eyepiece is 10x, the total magnification is 20x. Eyepiece magnifications range from 10x-40x. For most applications, 10x is adequate. Depending on the microscope you purchase, eyepiece magnification over 10x can cause aberration and vignetting. To obtain the detail and sharpness that you'll want, the objective lens is the critical one.

Zoom models are nice because they offer continuous magnification within their minimum and maximum range. The zoom ratio is the ratio between the highest and lowest magnification. For example, a common zoom objective lens would have a zoom range of 0.7 – 4.5x; dividing this out would result in a 6.4:1 zoom ratio.

The field of view is limited by the ocular tube diameter and

magnification. The ocular tube supports the eyepiece. For most hobbyist microscopes with 10x eyepieces, the inside diameter is usually 23mm, which is also the size of the field of view. When you move to 2x magnification, your field of view is 11.5mm. You calculate this by dividing the field of view by the magnification amount.

Resolution

The resolution of an image is related to the quality of the objective lens. An objective may provide a high magnification but if the view is blurry then the magnification does you no good.

Resolution is determined by a lens property called numerical aperture (NA)which in turn is related the diameter and focal length of the lens as well as the properties of the material between the lens and the specimen. Usually this is air (especially for stereo microscopes), but it could be oil or water.

The higher the NA the better the resolution. High-quality microscopes have an NA of 0.05 – 0.95; anything above 0.95 requires an oil immersion technique.

Many of the hobbyist-priced microscopes do not include NA information. I'm not sure why it isn't provided because it's important to assessing the quality of the microscope. If the dealer cannot provide you the NA, you need to ask for photos to be taken using the microscope or buy it, assess it yourself, and return it if it doesn't meet your criteria.

With a stereo microscope the working distance and the NA have an inverse relationship. The reason most folks want a stereo microscope is to be able to work under it, to dissect something or point an insect. Working distance decreases as magnification increases.

Optical Quality

Optical quality is defined by the type of objective lens in the microscope. More expensive lenses have more elements for correcting distortions due to limitations or defects in a lens. Most microscopes use an achromatic lens. Achromatic lenses correct for color aberrations and are sufficient for most hobbyist applications. The achromatic standard specifies that the center 60% of the field of view appear as flat and focused without distortion.

There are several other types of lenses available for microscope use, but these tend to be very expensive or of lower quality.

There are 4 types of lenses available for microscope use.

1. **Plan Apochromat** – (AKA Apo or Plan Apo) A modern, high-numerical aperture microscope objective lens designed with high degrees of corrections for various aberrations. It is corrected for spherical aberration in four wavelengths (dark blue, blue, green, and red), for chromatic aberration in more than these four wavelengths, and for flatness of field. A single plan Apo objective may contain as many as 11 lens elements.
2. **Achromatic Lenses –** When lenses are labeled as "achromatic" this means that they have been color corrected so that they will show true specimen color. If a lens were not achromatic, you might not be able to view all colors. Achromatic also refers to how much of the lens is focused and aberration-free. In an achromatic lens, 60% of the center of the lens surface is guaranteed to be focused and without aberrations or flaws.
3. **Plan Objectives –** Lenses that are 100% focused and without aberrations are called plan objectives. Scopes with plan objectives are usually used in the laboratory or medical fields as these type of lenses are very expensive.
4. **Semi-Plan Objectives –** Also available are semi-plan

objectives which are focused and aberration-free over 80% of the lens surface. Again, these scopes are more expensive and are usually reserved for the serious hobbyists or medical or lab professionals.

Comfort

The angle of the eyepieces and the width of them will increase your personal comfort when using a microscope. Widefield eyepieces are eyepiece lenses with a large lens area, often this is around 18mm. They allow clear viewing and easier eye positioning, providing eye relief when viewing objects for long periods of time.

Illumination

An important option to consider for your stereo microscope is illumination. The lowest priced stereo microscopes have no illumination system. A microscope that offers light sources above and below provides flexibility. The light from below is good when viewing specimens on a slide. Light from above is imperative for viewing large, non-transparent specimens but you may also need to use directed side lighting that can be attached to the microscope or that sits beside it.

The bottom line of my research is that a good working microscope, one that will provide quality viewing and the ability to work under it can find these at most online retailers. If you want good-to-OK photos get an adapter kit for your camera and attach it to the microscope. Do not waste your money on a dedicated camera for these inexpensive microscopes. If you want high quality photos using a microscope, you usually need to invest in one of the 4 major brands – Nikon, Olympus, Leica, Zeiss – which can run upwards of $10,000.

But…there is an affordable way to get those great-excellent photos with a microscope without spending $10,000+!! I'll explain about that in an upcoming article.