The Fine Art of Layering

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> Staying comfortable outside is a matter of dressing to outwit Mother Nature. It's a balancing act between the climate, your activity level, exposure time and tolerance to heat and cold. Choosing the right clothing and layering it properly can make the difference between a pleasant outdoor experience and an uncomfortable (or even dangerous) situation.
>
> —REI.com Expert Advice, "How to Layer Outerwear"

> Why do I need all this fancy stuff just to go running, blading or biking? Fair question. Like the introduction of Gore-Tex years ago, all this fabric and fiber mumbo jumbo has its skeptics, but they are fast falling by the wayside. You don't have to opt for this aerobic function/fashion statement, but why on earth would you not want to? It works and it works leagues better than anything that has come before. With an appropriate layering system of advanced materials, weather is no longer a discomfort or nuisance—it's just a pleasurable change of pace.
>
> —Michael Hodgson, from unknown website

Central Issues Addressed in This Article

Is there an ideal layering system for most wilderness travelers and, if so, what is it? Is the traditional three-layer system or some other layering system most effective for my needs? Can the principles of layering be applied to the extremities and to sleeping systems? Am I interested in developing layering into a "fine art" or science?

Introduction

The concept of "layering" is one of the foundational principles of safe and comfortable backcountry travel, especially when traveling in cold, wet and mountainous climates. It has probably been around, in one form or another, as

long as humans have traveled the earth.[1] The more demanding the climate, the more incentive there is to have a thorough understanding of various layering schemes and principles.

Most experienced backcountry travelers have already developed clothing systems that work reasonably well for the conditions to be encountered, but there is always more to learn. Part of this learning process is understanding the pros and cons of various "high-performance" fabrics (e.g., eVent cloth, micro polyester fleece, superfine merino wool, polypropylene laminates) developed by the outdoor industry. How many of these miracle(?) fabrics are real improvements and how much is just advertising hype is not easy to determine. Another consideration in layering involves learning alternative ways to use commonly available garments.

While most hiking and backpacking books touch on the subject of layering, most do not give it the treatment it deserves. This article will provide an in-depth analysis of layering and, in the process, propose a four-layer clothing system. To set the stage for an in-depth analysis, here is a working definition of "layering":

> *Layering is paying close attention to one's core temperature making sure not to get too hot or too cold by adding and subtracting appropriate fabric layers as needed.*

Besides this general goal of thermoregulation, the specific goals of most layering systems are to effectively combine the following elements: breathability, wicking, rapid drying, insulation, durability, freedom of movement, wind resistance and water repellence while still being relatively lightweight. Achieving these goals involves an interesting challenge.

Stereotypical Approaches to Layering

There are many approaches to layering. Here are five simplified and somewhat stereotypical approaches for your consideration.

— Quickly shove some extra clothes in a pack without much forethought.

[1] It is interesting to note that in its Winter 2009 catalog, Patagonia claims to have introduced the concept of layering in the 1970s.

— Adhere religiously to the traditional "three layer" system: a base layer for wicking moisture, a middle layer for insulation, and a shell layer for blocking wind and keeping out precipitation.

— Carry the latest and greatest high-tech performance clothing recommended by outdoor retailers, manufacturers and publications. Especially important are "soft shell" clothing layers that it is often claimed can replace the traditional three layers with one or two garments.

— Follow your author's lead by adopting a flexible four-layer clothing system.

— Develop the expertise necessary to make intelligent decisions about layering strategies and how they apply in the climate(s) traveled.

Since the overriding purpose of this website is for you to develop an in-depth understanding of the topics covered and to make your own decisions, the last approach is recommended (even if you reject the author's recommended four-layer system).

Recommended Four-Layer Clothing System[2]

Over the years I have experimented with many different layering options to better understand the basic principles and their nuances. The various sections in this article detail what I have learned. Even though a three-layer system is traditional and almost universal, a more effective approach is to think in terms of four distinct layers, with variations for each. Here is an overview of the four distinct layers to be covered in this section:

1st - Moisture and Heat Management

2nd - Wind Blocking/Water Resistance/ First Tier Insulation

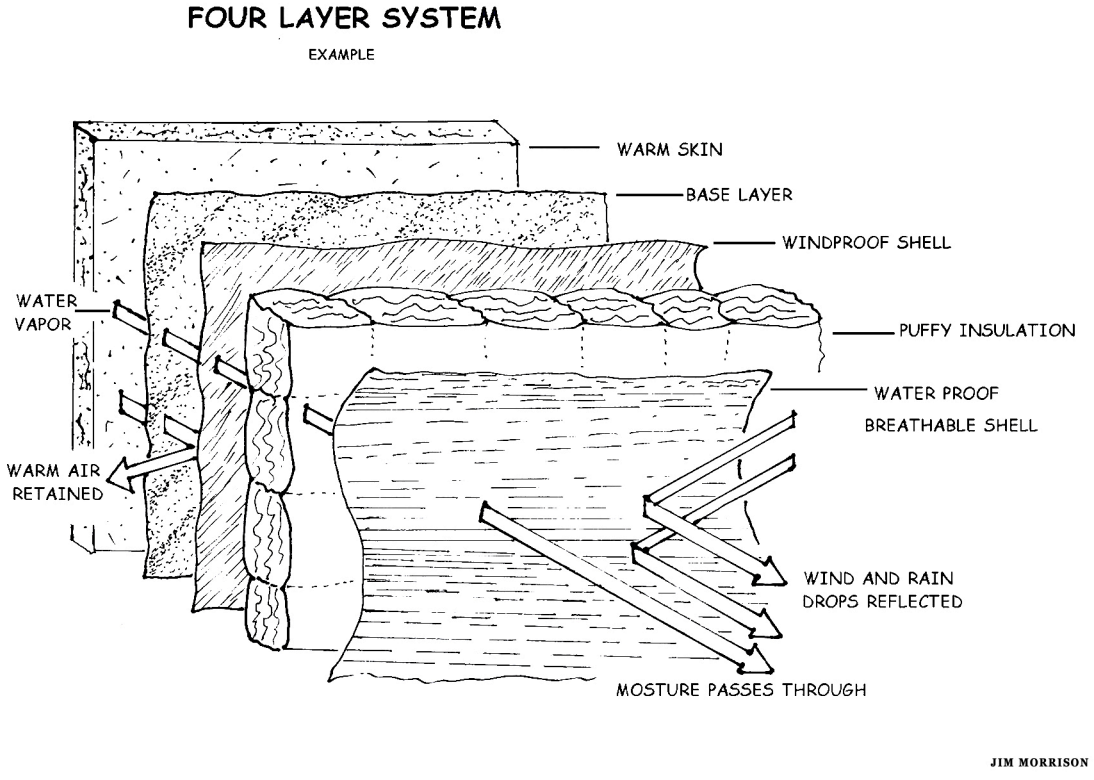
3rd - Increasing the Insulation Value

4th - Full On Storm Protection

[2] *Disclaimer*: I claim no originality for this four-layer system; variations of it appear here and there in the literature.

Each of these four distinct layers has its own *function* and purpose. Within each of these functional layers, there could be multiple sub-layers. For example, I often wear two first-layer garments (usually one very thin short sleeve and one slightly heavier long sleeve underwear pieces). Consequently, on any specific trip (especially those during the shoulder seasons) I might be carrying or wearing six or more actual clothing layers. The four-layer system described in the next several sections refers to *function*, not the actual number of layers.

The next few sections provide detailed information about each of the four layers taken individually. After detailing the four *functional* layers, suggestions for refining the layering system (viewed as a whole) are offered. I then expand the principles of layering to the extremities and to sleeping systems. Whether one adopts a three-layer, four-layer or some other layering system, this article will provide a lot of useful information about layering.



First Layer: Moisture and Heat Management

This base (next-to-the-skin, innermost) layer manages the heat and moisture the body generates during strenuous physical activity. This first base layer usually consists of some combination of the following: underpants and sports bras,

hiking shorts, tank tops and short sleeve shirts, long sleeve underwear tops, tights or long-john underwear bottoms.

Base layer clothing usually comes in several weights. Words such as “silk,” “micro,” “light,” “mid” and “expedition” are used by manufacturers to delineate these weights. At least one well known company uses a numbering system (1-4) for their weight designations. The common fabrics for base layers are silk, polyester, polypropylene, merino wool or some combination of these. There is currently much debate about the durability, wickability, temperature control, and smell factor of these competing fabrics. Of the fabrics currently available, a popular choice for base layers is a combination of merino wool and polyester (in varying percentages in the same garment or two separate garments) to capture the advantages of both. Merino wool is often used for trail wear because one can wear these garments for several days without smell becoming a factor. Manufacturers continue to refine their “high-performance” base layer clothing making the differences between competing fabrics less obvious and more difficult to assess.

Wickability (i.e., moisture transference properties) is probably the most important feature of first base layer fabrics since water is so good at pulling heat from your body. Ideally, this first base layer will wick and transfer all perspiration away from the skin. In reality, these layers will usually be damp from sweat during rigorous exercise (sometimes “wetted out”) no matter how good the moisture transfer properties of the chosen material. Inexpensive base layers purchased at discount and chain retail stores often work quite well under moderate conditions.

Though quite debatable, generally avoid cotton clothing in the backcountry in all seasons and conditions because it wicks easily, dries very slowly and pulls heat from the body (generally not good). Many wear cotton in hot weather conditions with the rationale that it assists evaporative cooling of the body. One problem with this practice is that evaporative cooling requires the transfer of moisture from the body through the fabric to the outside. Cotton readily absorbs moisture but tends to hold onto it, thereby reducing the cooling effect (especially when compared to other fabrics). The higher the humidity levels, the more reduced the cooling.

Second layer: Wind Blocking/Water Resistance/First Tier Insulation

A separate wind- and water-resistant layer is essential in a high-performance, layered clothing system. This shell layer is unlined and not waterproof. Here is one strong advocate of windshells:

> The addition of a 3-ounce breathable windshirt extends the comfort range of your clothing in high winds, cool temperatures, and light rain like no other layer. A poncho, windshirt and your base layers provide you with enough warmth and protection to cover 90 percent of the inclement weather you'll encounter during summers in the Continental US mountain ranges.
>
> —Ryan Jordan, "SuperUltralight," *Lightweight Backpacking & Camping*

The windshell layer is usually made from tightly woven nylon or polyester fabrics and constructed in one of five configurations: button-up long sleeve shirt, sleeveless vest, full or partial zip wind jacket; full or partial zip parka with hood. Windshell jackets and parkas can be found weighing as little as 2-3 ounces. This layer has the potential of providing much benefit for so little weight. For the lower body, thin water- and wind-resistant pants (e.g., ripstop nylon or nylon Supplex fabric pants with zip-off legs) serve the same function.

Conceptually, this layer has at least three features (besides style and aesthetics). *First*, it is tightly woven in order to minimize the amount of moisture getting in from the outside (as well as keeping sun and insects out). *Second*, it is highly breathable to quickly transfer moisture from perspiration to the outside (i.e., it slows down evaporative cooling). *Third*, it is wind-resistant enough to prevent convective heat loss. If the base layer gets saturated ("wets out"), the wind shirt layer will restrict heat loss so that the saturated layer is kept close to skin temperature for you to remain comfortable (i.e., a wet suit effect). This third feature essentially functions as insulation because of the dead air space created (the higher the level of wind resistance, the greater the insulation factor).

Three criteria are essential for these three features or functions detailed above to work well:

- enough body heat is generated to push back incoming moisture by drying the fabric faster than it can get wet
- wicking base layers are efficient in transferring the moisture from perspiration away from the skin
- a broad surface is created whereby moisture (either from within or without) can be picked up by the wind and transferred out into the environment.

This second-layer garment is usually treated with a durable water-resistant (DWR) outer finish that needs to be renewed regularly to maximize water resistance. If so treated, it will function well for light rain and snow protection. Since this second-layer garment can also be used as a first base layer, especially if it is hot and you desire some sun and bug protection, make sure it is soft enough to wear against your skin.

Even though contemporary waterproof fabrics (e.g., Goretex and eVent) are becoming more breathable, they are generally not breathable enough to satisfy the criteria for this second laying category. *Exception*: well-conditioned individuals involved in moderate levels of exercise wearing highly breathable garments who are genetically programmed to lower levels of sweating. Most hikers are not exceptional and do not satisfy these conditions and will find waterproof/breathable shells unsatisfactory for this second layer while hiking.

For more detailed information about layering with windshells, click on Wind Shells as an Essential Part of a Layering System.

Third Layer: Increasing the Insulation Value

This third layer in a clothing system is designed specifically to greatly *increase* the insulation value when the body significantly *decreases* its heat production. Even though this third layer is the primary insulation layer, the first two layers provide some first tier insulation depending upon their thickness and tightness of weave. The fourth (storm shell) layer also provides some insulation because of the tight weave of waterproof fabrics.

One principle of insulation is to trap as much warm air as possible. Air is not good at conducting heat and is, therefore, a good insulator. Water is a very poor insulator. Therefore, this third insulating layer should not only trap air but also be made with fibers that minimize the retention of moisture. The more efficient this dead air space (dryness and trapped air), the more warmth is potentially trapped. It is important to understand (if not already clear) that insulating garments don't produce warmth by themselves; they only slow down the loss of body heat. The more effective the insulation the slower the loss.

There are great individual differences in this third layer insulation requirement. These differences depend upon factors like gender, body fat layers, body metabolism, activity levels, fitness levels, climate, humidity, exposure time,

and conditioning to colder outside temperatures. What works well for some may not work for others.

This third layer traditionally comes in the following configurations: button-up long sleeve shirts, pullover sweaters, sleeveless vests, quilted jackets and parkas. More radical insulation alternatives include vests constructed with shoulders but minimal sleeves and sleeping bags with armholes and foot openings that can be worn as insulation while walking around. Some “ultralighters” use these wearable bags in lieu of more traditional forms of insulated clothing.

Even though all fabrics insulate to some degree, the most efficient fabrics for this third layer of outdoor clothing are currently hydrophobic polyester batting (e.g., Polarguard, Exceloft, Primaloft), polyester fleece pile (e.g., Polartec), wool and goose down. More radical high-tech options currently available include a sewn-in battery enhanced heating system and inflatable jackets lined with solar reflective materials.

Among the currently competing insulating fabrics, there is ongoing debate over durability, drying capacity, warmth-to-weight ratio, and maintenance of dead air space (loft) when wet. Goose down has the superior warmth-to-weight ratio (fleece and wool are the worst). Wool and fleece have the greatest durability. Fleece insulation also has the best drying and breathability characteristics. The preferred *primary* insulation garment in wetter climates is often hydrophobic polyester batting quilted between tightly woven nylon shell layers. The nylon shell layers increase wind resistance and dead air space. Also becoming more popular are bi-component “softshell” garments combining polyester fleece with wind- and water-resistant fibers. If the polyester quilted garment is your preference, be careful about compressing the garment too tightly as most polyester quilting loses its loft more rapidly than other options with repeated compressions.

Whichever insulating materials and configurations are selected, loft is the primary indicator of insulation value. The more loft, the greater the dead air space created. The ideal is a maximum loft with the least amount of moisture retention. With down insulation, fill weight (amount of down in the spaces) is probably a better indicator of insulation value. Secondary concerns for this third layer are usually weight, price, packability and durability.

Fourth Layer: Full-On Storm Protection

The first three layers presented provide considerable protection from the elements. However, there are times when we will take all the protection we can get. For the *upper body*, this outermost, weatherproof layer comes in at least four configurations: hooded or non-hooded ponchos, non-hooded jackets with rain hats, full or partial zip hooded parkas, extra length hooded parkas ("cagoules"). A more radical, hybrid garment called the "packa" attempts to combine the features of a poncho, hooded parka and pack cover. For the *lower body*, this fourth layer comes in at least five configurations: chaps, kilt, full-zip pants, pants with no zips (except maybe ankle zips) and bibbed pants. Most of these garments come in both breathable or non-breathable fabric options.

The most common waterproof and breathable fabrics currently available are Goretex, eVent and Propore. In addition, companies like GoLite, Marmot, Montbell, REI, Outdoor Research, Patagonia, Redledge, Sierra Designs, Columbia and The North Face use their own proprietary fabrics (usually some form of microporous polyurethane coating) for their storm protection clothing. eVent is seldom advertised as such but used by some of the above companies as aproprietary fabric. Propore (a non-woven, microporous polypropylene laminated fabric) is less well known. It is retailed under names like FrogToggs, DriDucks and Drop Stoppers. It is very lightweight, inexpensive but somewhat fragile. Because of this fragility, if using this alternative fabric consider wearing your wind shells (second layer) on top of the polypropylene for protection in rough conditions.

The year 2011 saw the introduction of several new waterproof and breathable fabrics. At this writing, the reviews of their effectiveness for the purpose of hiking and backpacking are starting to come in. *Backpacking Light* has run a 3-Part series detail their findings: Field Testing Air Permeable Waterproof-Breathable Fabric Technologies – Part 2: Are There Detectable Differences Under Real World Backpacking Conditions? Unfortunately, the articles are available only to subscribers.

Even though debatable, the most preferred and versatile configuration for full-on storm protection is a full zip storm parka, slip on pants, brimmed rain hat and gaiters—all made from waterproof *and breathable* fabrics. The *breathable* feature of these waterproof garments is especially valuable for using body heat to dry other layers when the hiker is either stopped or is in a reduced perspiration mode. This "clothes-drying" characteristic of waterproof and breathable fabrics is an important consideration in selecting this fourth layer (i.e., a highly breathable

fabric). Maintaining the durable water-resistant (DWR) coating usually found on most of these fabrics is essential to their breathability. To not plug up the breathability pores, DWR renewal treatments should generally be sprayed on rather than washed in.

Non-breathable, waterproof fabrics are often used for these fourth layer storm shell garments. They do just fine in extreme conditions when the hiker is not involved in highly aerobic activities, but obviously do poorly with the "clothes-drying" property discussed in the previous paragraph.

Another characteristic of this fourth shell layer is its third tier insulation properties. Being windproof, these garments provide some additional dead air space even though there is little additional loft. Stated more broadly, all of the garments in recommended three and four-layer systems provide different degrees of insulation.

Further Refinements to Layering Systems

No matter how many layers in a clothing system, there are many refinements for those interested in developing the art of layering. Here are several potential refinements for your consideration.

Variability: Specific clothing preferences should not be fixed and should change from trip to trip and season to season. This is especially true when experimenting with new clothing options. In presenting a four-layer clothing system, I acknowledge that one or more of the four layers might be left out of the pack for shorter hikes in good weather or when hiking in hot climates. Even when leaving out one or more of the four layers, consider carrying an emergency bivy sack on day trips to provide additional shelter from the elements.

Venting: Venting is an obvious complement to breathability and layering. There are many good venting options: full front zips on jackets and parkas; pit zips on shirts and jackets, neck zips for base layer tops; convertible pants with zip-off legs; side zips on storm pants, adjustable cuff closures; sleeves or pant legs that can be rolled up or down as needed.

Doubling Up with Lighter Weight Garments: For flexibility, thinner and lighter weight garments are preferable to heavier items. In more extreme

conditions, consider carrying two or more lightweight clothing options for each of the four layers. For example, I usually carry two base layer garments, two windblock layers (a thin button-up wind shirt and a zip-up wind parka) and I often carry an umbrella to supplement my storm parka. For the third insulation layer, I often carry a long sleeve fleece shirt combined with either a lightweight quilted parka or a down vest. The overriding principle here is to maximize the number of layering options while minimizing the total weight and bulk.

Keep Your Insulation Dry

Do whatever is necessary to keep your powder (whoops, I mean insulation) dry! If you use a four-layer system and follow the above doubling up recommendations, there will seldom be a need to wear any third level insulation layers while hiking, thereby keeping them dry in your pack.

Keeping Body Core Comfortably Cool: Even though we naturally want to feel warm and comfortable while hiking, consider erring on the cool side to prevent build-up of unwanted moisture from perspiration. Following this guidance will result in fewer stops to adjust clothing layers. Overheating saps strength and endurance more than the few extra calories expended keeping warm while cool. Overheating can also set up the conditions for hypothermia. An example of erring on the cool side is to start out with a layering combination that will still feel slightly cool after 10-15 minutes on the trail (often just a base layer and a wind shirt layer). Experience will dictate the right amount of layering to remain comfortably cool for the conditions.

Anticipate Layering Needs: The more experience with layering, the easier it is to predict the best layers for what lies immediately ahead. One example is given immediately above: err on the cool side when starting out from the trailhead. Another example is coming up to a pass where you are reasonably sure it will be cold and windy. Stop just before the pass to add layers and build up a little extra warmth on the rest of the way up. While still at the pass, take off the extra layers just before leaving.

Different Fabrics in the Same Garment: Quality “performance” outdoor clothing often uses more than one type of fabric in the same garment. A

common example would be a tightly woven nylon shell covering for a polyester quilted or down filled parka. Another example would be bi-component construction when different types of materials are woven into the same piece of cloth (e.g., Lycra for stretch, windblock material for wind and water resistance, all added to microfleece insulation). Another popular bi-component construction is merino wool combined with either silk or polyester in base layers. A final example is to use different fabrics in different areas of the garment. For example: a more durable and water resistant fabric on the shoulders, more breathable fabrics on the backside and the underarms, and more wind-resistant fabrics sewn or woven into the front panels. This latter feature is good for sports such as skiing and mountain biking when speed can accelerate thermal loss from wind chill. The downside of all of these variations is that it makes the selection of high performance outdoor clothing more difficult.

Outside Pockets: For quick access to various layering options without stopping to get inside the pack, consider outside pockets on parkas, pants, windshirts and packs.

Additions for Extreme Cold Environments: When encountering Arctic-like conditions, several interesting additions can be made to standard layering systems: quilted pants, down booties, vapor barrier liners, reflectorized coatings to reduce radiant heat loss, fur lined parka hoods (especially Wolverine fur), animal fur overboots, closed cell foam sandwiched overboots, battery and chemically activated heat sources. My experience says that vapor barrier liners should be the first line of defense in layering for these conditions. Excepting the brief mention in this section, the art of layering for extreme cold environments is outside the scope of this article.

Layering Principles Applied to the Extremities

Layering principles can be applied to the feet, head, neck and hands. Layering principles fully applied to the *feet* usually result in the following combination: a thin wicking liner sock for the first layer, one or two thicker socks for the insulation layer, and gaiters for an additional storm shell layer. A waterproof boot or shoe liner or sock (breathable or non-breathable) is sometimes added to this combination. Care should be taken not to overinsulate the feet. Overinsulated

feet are not only heavier to move, but tend to sweat more than necessary. Excess sweating (produced by waterproof and breathable boot or shoe liners?) could mean colder feet and more difficulty in drying socks. Even though layering is often applied to the feet in colder weather, the overriding principle should be to keep the core warm. A warm body core will greatly reduce the need for applying additional layers to the feet. Some warm-blooded individuals get by with wearing only liner or dress socks in their trail shoes for all but the coldest weather.

Layering principles can easily be applied to the *head and neck* in colder weather. A full layering system for the *head* could produce the following combination: a very thin first layer polyester beanie for wicking and dead air space insulation caused by the hair layer (assuming there is some head hair), a thicker insulating cap or beanie to supplement the first as needed, and an ear band to supplement the first two layers. These three layers take up little space and can weigh as little as 3-4 ounces total. For the fourth layer (i.e., "full-on storm protection"), hooded parkas work well for the head and neck. In winter-like conditions, add a neck gaiter or balaclava for additional insulation.

Layering principles can easily be applied to the *hands*. A full layering system for the *hands* could result in the following combination: a thin pair of gloves for the first layer, a thicker pair of mittens (usually wool or microfleece) to supplement the first layer as needed, and a waterproof and breathable pair of shell mittens for the storm protection layer. A wind shell layer is not ordinarily needed for the hands, although a windblock fabric of some kind is often added to enhance the performance of insulating gloves and mittens. An interesting layering option is to carry two thicknesses and two sizes of *gloves* (e.g., a thin size medium and a slightly thicker size large), wearing both as the temperatures get colder. Also popular is an inner glove and an outer mitten combined in one garment.

Layering Principles Applied to Sleeping Systems

Layering principles are often applied to sleeping systems even though, traditionally, backpackers have opted for one heavier sleeping bag to cover the worst conditions that might be encountered. Instead of a general discussion of options (of which there are many), following are my own preferences.

My ideal sleeping system would cover a full range of temperatures from the 60s down into the low 20s. Using laying principles, start with a zippered down mummy bag weighing 20 ounces or less covered by a water-resistant and

breathable bivy sack weighing 8 oz. or less. The bivy could be the only bag in hot weather or it could add 5-10 degrees to the sleeping bag when it gets colder. The bag should have at least a 2/3 length zipper so that it can be used as a quilt. The girth of the bag should be sized so both shell clothing and insulated jackets can be worn to bed without compressing the insulations. Insulated jackets should be made of synthetics in case the down bag gets wet for some reason. Using a total of six layers (bivy sack, down bag, insulated jacket, wind shell layer, long underwear base layer, short sleeve underwear) will ordinarily take this ideal sleeping system into the low 20s. Extra socks, gloves and hat layers can be added as needed. To take this system down into even lower temperatures, consider adding storm shells, a vapor barrier shirt and quilted synthetic pants. My ideal layered sleeping system would also include two sleeping mats for the coldest weather.

Maintaining the option of wearing all four layers of clothing (as defined in the early part of this article) to bed allows for carrying a much lighter sleeping bag (sometimes weighing as little as a pound or less). It offers a lot of flexibility for a wide range of temperatures. Wearing your extra clothes to bed also means reduced time getting ready for bed and getting on the trail in the morning. The extra warmth generated is useful for drying out damp trail clothes. I acknowledge that some backcountry travelers insist on sleepwear separate from their daywear and would never consider wearing damp and dirty trail clothes to bed. However, this seems to be a matter of taste and habit, not of necessity. See the webstore article on “Alternative Sleeping Systems” for an in-depth discussion of this controversial issue of wearing extra clothes inside sleeping bags.

One additional but obvious application of the layering principle to sleeping systems is to combine sleeping bags/quilts. The most common is to layer lighter-weight sleeping bags for cold weather (or purchase a sleeping system that is designed with an inner and outer bag). The option I am currently experimenting with is adding a lightweight (12 oz) synthetic quilt on top of a light weight (18 oz) mummy bag. Not only does this system provide for a wide range of temperatures, it solves the draft problem endemic to quilts. When really cold, I can breath warm air from under the quilt. This system also works well with my single-wall tarp-tent which sometimes drips condensation (the synthetic quilt acting as a sacrificial layer to protect my down sleeping bag).

Main Points of Layering

This article is called “The Fine Art of Layering” because there are many principles and judgment calls for developing an efficient and effective layered clothing system. Here is a summary of the main points.

— Layering is both an art and a science; it is an art that requires skill and imagination; it is a science that requires some understanding of principles of thermoregulation.

— There are great differences in the layering requirements of individuals depending on factors like gender, fat layers, body metabolism, activity levels, fitness levels, climate, exposure time, and conditioning to cold outside temperatures.

— Develop your own expertise regarding the art and science of layering; make your own decisions about how layering principles apply to your personal hiking needs and circumstances.

— Adding a thin wind shell layer to the traditional three-layer system can provide much benefit with very little volume and weight; an argument can be made that it is the most important layer.

— Even though the principles of layering are most important when applied to the upper body, they can easily be applied to the extremities and to one’s sleeping system.

— Besides the overall general goal of thermoregulation (controlling body temperature), the most effective layering system combines elements of breathability, wicking, rapid drying, insulation, durability, freedom of movement, wind resistance and water repellence, while still being relatively lightweight.

— Achieving the above goals involves experimentation, critical judgment and often compromise.

— Not understanding the art of layering can lead to unwanted evaporative cooling, much discomfort and dangerous medical conditions like frostbite and hypothermia.

— Not understanding the art of layering can result in overheating, which increases dehydration and zaps energy and even heatstroke if severe enough.

— All four layers in a four-layer system provide some degree of insulation to protect against getting too cold. All four layers can also contribute to getting overheated if not willing to shed layers.

— In temperate, lowland climates during the summer, almost anything goes regarding a clothing system; it is cold and wet and mountainous climates that require the most planning and understanding of the art and science of layering.

Additional Issues for Reflection

1. Ideal Layering System: Is there an ideal layering system for all wilderness travelers in all environments? Is the layering system presented in this article applicable to most environments? How variable are layering needs in various types of wilderness travel?

2. Three vs. Four Layer Systems: Is the four-layer system presented in this article a significant improvement over the traditional three-layer system? Would it be better to think mainly about how many total layers of clothing are needed for a particular trip rather than whether you have a two-, three- or four-layer system?

3. Soft Shell Garments: Are high-tech, soft shell clothing options making both three- and four-layer systems obsolete? Are they the next evolution of clothing systems?

4. Soft Shells Related to Personal Values: Assuming that multi-purpose soft shell garments require less layering changes and assuming that soft shells are less efficient than standard layering practices regarding

thermoregulation, what are your values in this regard? For example, how important is it to have the most accurate and finely turned thermoregulation? How important is speed and ease of travel without having to stop to change? How important is it to be on the cutting edge of the performance outdoor clothing industry?

5. Expensive, High Performance Clothing: Granted that one can travel the backcountry without expensive high-performance clothing (e.g., buying used or military surplus or from discount chains), how important is it to be on the cutting edge? Assuming you can afford high-performance clothing, is this a priority for you?

6. High-Performance Claims: How should manufacturers' and retailers' claims regarding high-performance clothing be assessed? How useful are gear-testing organizations in this regard? How objective are clothing reviews in outdoor magazines where manufacturers and retailers advertise heavily?

7. Natural vs. Synthetic Fabrics: How important is it to backpack with clothing made mostly from natural fibers (wool, cotton, silk) rather than synthetics (nylon, polyester, polypropylene)? Can one learn to layer natural fiber clothing in ways that are comfortable, functional and safe? What about the wisdom of wearing cotton in hot and dry conditions in the backcountry?

8. Military Surplus: What about using military surplus for outdoor clothing? Has the U. S. military successfully gotten into the high-tech, high-performance clothing game?

9. Heavy, Expensive Storm Gear: To maximize the outer, "full-on" storm level of protection, is it necessary to purchase expensive, high-tech parkas in the 1.5-2.5 pound range?

10. Merino Wool Garments: What about the claims for and against merino base layers when compared with high-performance polyesters? Is the decision by mainstream outdoor clothing manufacturers to offer many

more wool items and wool blends a matter of enhanced performance, or following the latest fads? What about the continuing strong preference for merino wool socks?

11. Garments Adapting to Conditions: What about advertising claims that garments can chemically sense temperatures and moisture levels and change with thermal regulation needs?

12. Close-Fitting Garments: When are stretchy, close-fitting garments a benefit and when are they a detriment? Do stretchy fabrics like Lycra and Spandex wick as well as other base layer fabrics? Are sleeping bags that fit close to the body by incorporating stretchy fabric (e.g., the Hugger series by Montbell) superior to standard designs?

13. Little Excess Fat: Are there different layering principles for those who are thin or who carry little or no excess fat? Are rates of metabolism more important than the amount of body fat?

14. Sweating Extremes: Are there different layering principles for those who sweat profusely most of the time? For those who sweat much less than average? Should clothing fabric be different if one experiences one of these extremes?