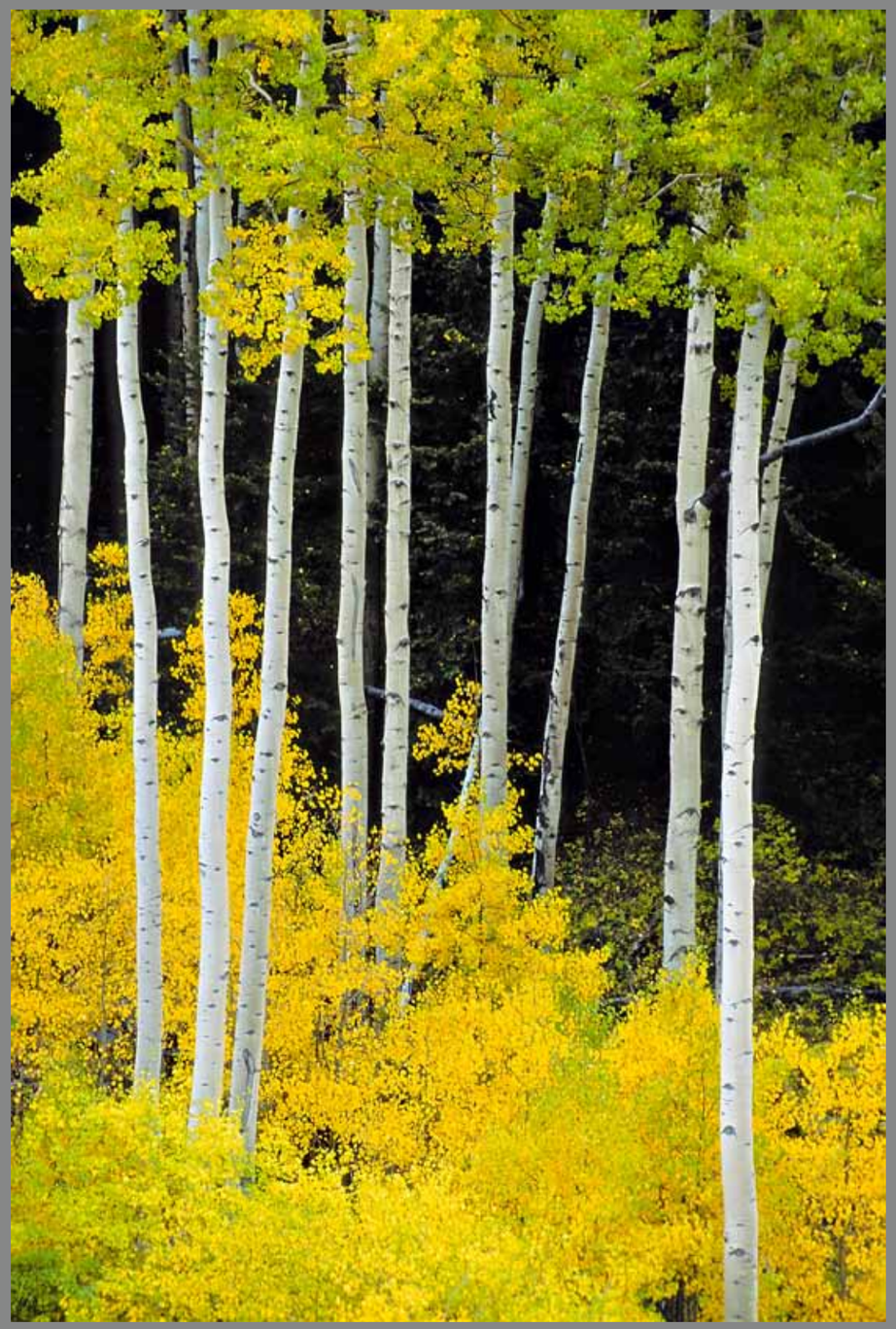
FORESTS OF LIGHT

THE ROMANCE OF ROCKY MOUNTAIN ASPENS



BY LINDE WAIDHOFER

This electronic photo book is designed to open in so called "full screen mode" on a black background with no distracting menus.

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FORESTS OF LIGHT

THE ROMANCE OF ROCKY MOUNTAIN ASPENS

LINDE WAIDHOFER

FORESTS OF LIGHT

TEXT, LITO TEJADA-FLORES

ESSAY, AUDREY BENEDICT

A WESTERN EYE BOOK

FORESTS OF LIGHT

THE ROMANCE OF ROCKY MOUNTAIN ASPENS

LINDE WAIDHOFER

FORESTS OF LIGHT

The patient circle of a Rocky Mountain year turns on an axis of tall trees – aspen trees. Quaking aspens, *populus tremuloides*, moving into mountain watersheds after forest fires, capturing the terrain by sprouting a clone forest from a common root system, capturing our hearts without a fight. Aspen forests are platonic forests, as pure and perfect as child's idea of a forest, or an artist's dream of a forest, painted on a dark Rocky Mountain canvas in straight lines and clouds of color, painted with light, absorbing the high-altitude light, then giving back more light than they absorb, generous, prodigal with light.... Forests of light.

Aspen forests mark the slow progress of the seasons in subtle shades, subtle variations on their themes of white and green, yellow gold and red. As if the sum total of light dancing through these tall minimalist forests remained constant, only the wavelength, the color shifting over time. Even in midsummer, leaves darken daily while trunks shine paler and paler. And then the long chromatic landslide toward autumn. One leaf at a time, one tree, one clonal group of trees,

one forest—among aspens, the forest is the tree—sliding back down the spectrum in an end-of-summer palindrome of green to lime to lemon, then beyond into the incendiary firelight of deep autumn. Sunset colors at high noon. Forests glowing, pulsing, vibrating with colored light.

Autumn fires fade but light still pours out of these enchanted aspens. The last leaves are achingly bright. And as they slip off in the wind, the trunks begin to shine, bleached white bones in the year's twilight, the vertical architecture of a forest lit from within. Long aspen fingers comb the first snowflakes out of grey December skies, whole mountainsides move toward a monochrome tapestry of white on white. Light no longer filtered through leaves, no longer diffuse and soft, condenses and sparkles from winter crystals, snow, ice, hoarfrost. Imperceptibly, the sun starts its long pilgrimage back north, deposits its gift of light at the foot of each aspen, whispers promises of warmth and color, promises that this endless round of light will truly never end.

AUTUMN INTO WINTER

THESE ARE THE FIRST OF THE LAST DAYS.

Autumn among the aspens. Deep autumn, a season shot through and through with symbolism: death and rebirth, all that. The slow rebirth of leaves as light. Logic against love, sense versus sentiment, old schism between feeling and fact: autumn beauty just froth on the deep tide of life, meaning's sharp teeth.… Still, for weeks we see everything through a yellow prism. Autumn asks its questions from a yellow book, doesn't wait for answers, moves on through a labyrinth of bare trunks in search of winter, color in search of calm, of cold, of white...

And one day autumn's over. At long leafless last. Overnight we watched it go and forgot all that crazy color by breakfast. Those slow burning days, how a leaf carpet can cover a whole mountain range, the slow sigh of wind stripping each golden tree bare, white, bleak. Over now, and finished. Overnight we can't even remember a single red-gold tree; all we see is winter, one perfect flake multiplied, drifted, driven on the wind, a new story, newly told.

PLATE 1 CUMBRES PASS

PLATE 2 KEBLER PASS, ELK MOUNTAINS

PLATE 3 NEAR DURANGO

PLATE 4 FIRST SNOW, SAN MIGUEL PEAKS

PLATE 5

HAYDEN PEAK

SAN JUANS

PLATE 6 WILSON PEAK, SAN JUANS

PLATES 7 & 8

NEAR LAKE CITY

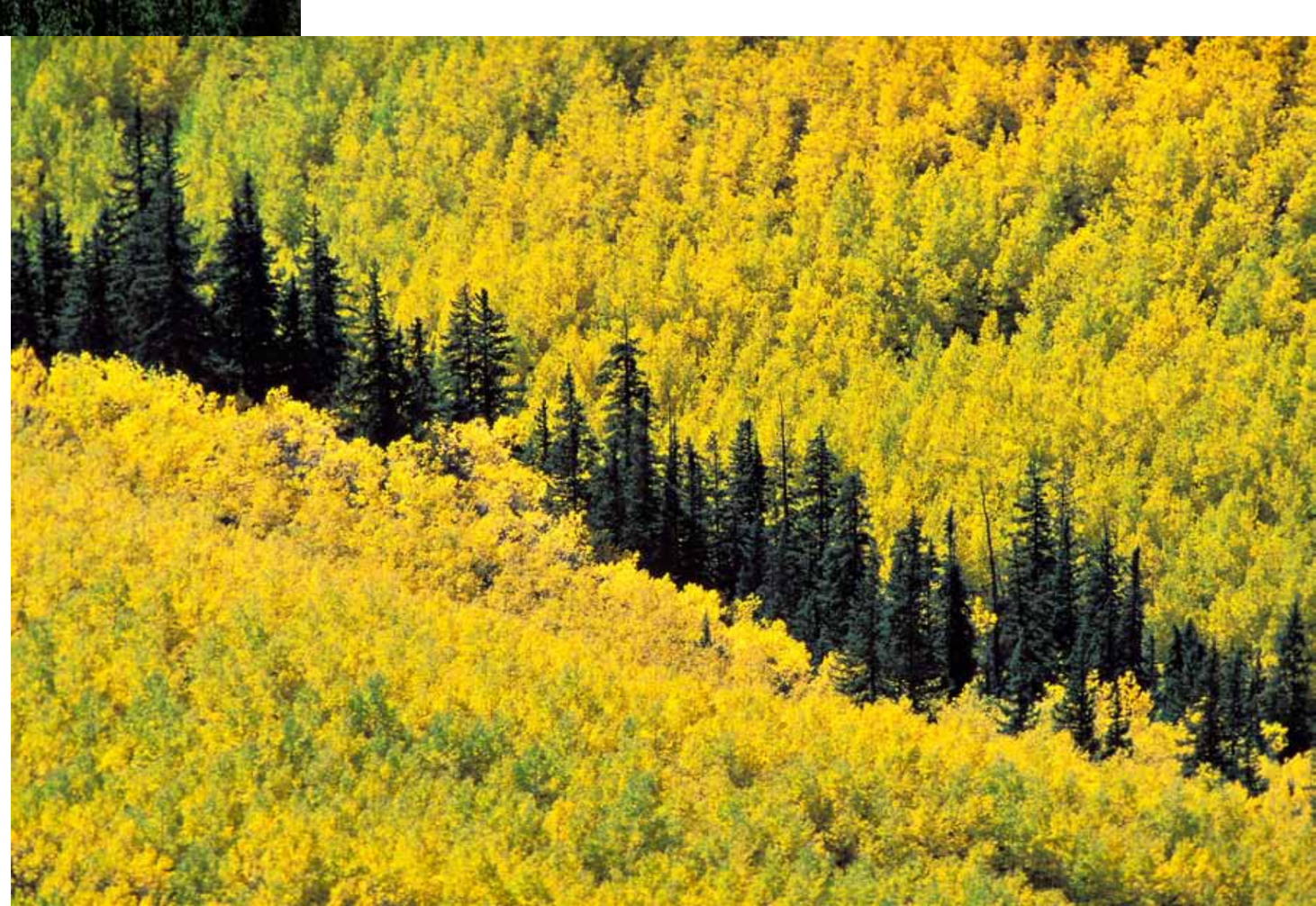


PLATE 9 BELOW OPHIR PASS

PLATE 10

NEAR
OWL CREEK
PASS

PLATE 11 ON WILSON MESA

PLATE 12 FIRE & ICE

PLATE 13 DOLORES RIVER CANYON

PLATE 14 SANGRE DE CRISTOS

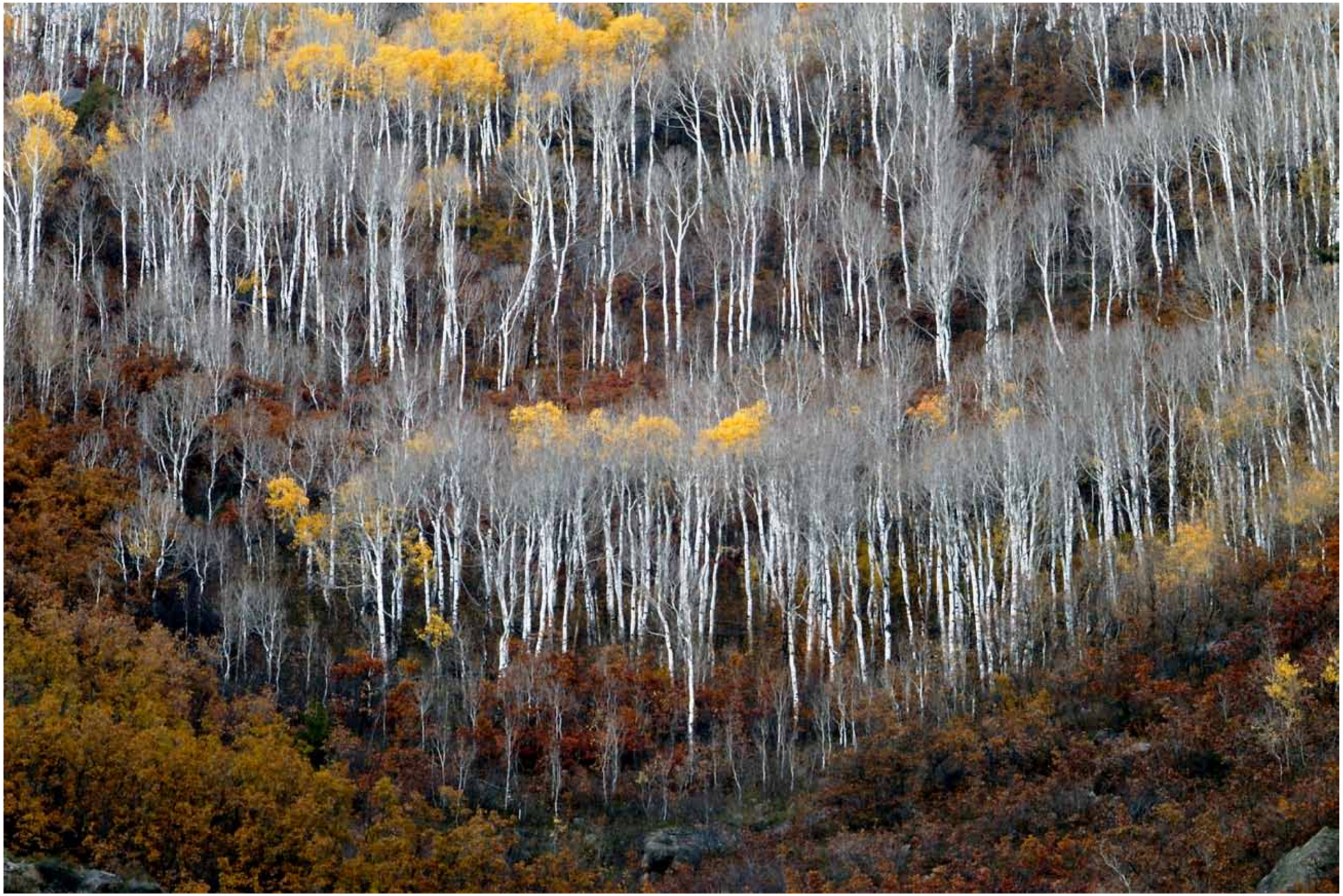


PLATE 15 INDEPENDENCE PASS

PLATE 16 McCLURE PASS

PLATE 17 UNDER AJAX PEAK, TELLURIDE

PLATE 18 TELLURIDE VALLEY

WINTER INTO SPRING

ENTERING WINTER, A LONG WHITE TUNNEL, walking over frozen ground, packing steps into snow. White days under a white sky, or gray, or even blue, but no more cottony cumulus tumbling over ridge tops. Winter's as much pale frosted light as snow, as much pale sky as cold air, as much frosted glass as frozen river. Got to assume green at the end of this tunnel; a long winter's wait for green. A long frozen season of frozen beauty, These aspen forests in winter are all architecture not décor, all skeleton not skin or hair, not wood or leaf, but light, these pure lines of white.

And one day we wake up from winter. Rubbing our eyes at the first tiny dots of green. Rubbing our eyes in disbelief. We have almost forgotten warm air, growing things, almost forgotten a world of more than one or two colors. Green drifts into the forest, through the aspens, like a fine mist. Aspen groves thicken from abstractions back into real trees, one stand at a time. It's time. Green is here to stay, other colors follow. We follow, stumbling out of this long cold tunnel into a real forest, standing up, stretching, running, shouting.

PLATE 19 CASTLE CREEK

PLATE 20

ALONG THE CRYSTAL RIVER

PLATE 21 NEAR TELLURIDE

PLATE 22 ON TURKEY CREEK MESA

PLATE 23 ALONG THE ROARING FORK

P L A T E 2 4

I L L I U M

V A L L E Y

S A N

J U A N S

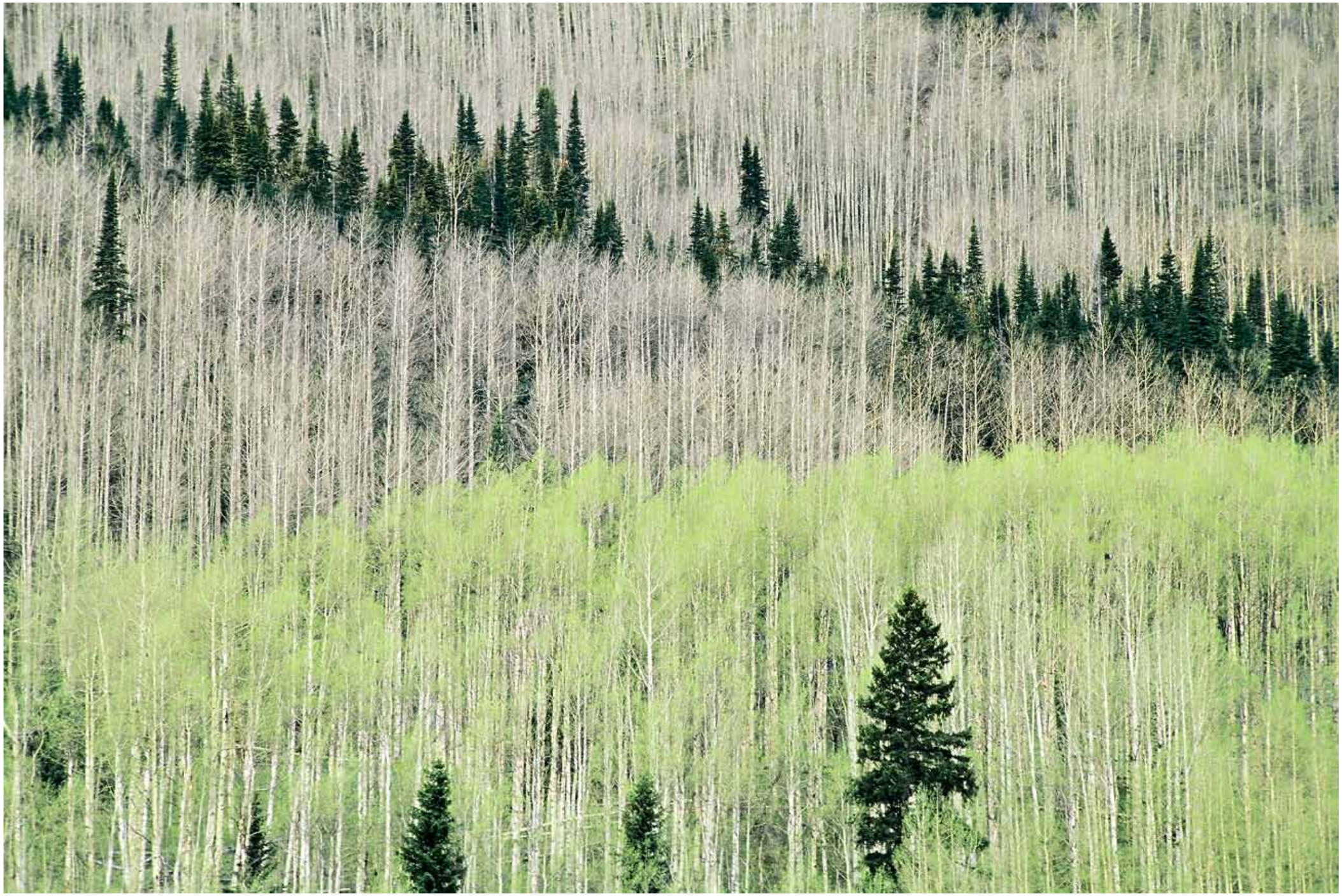


PLATE 25 NEAR TERROR CREEK

PLATE 26 ILLIUM VALLEY

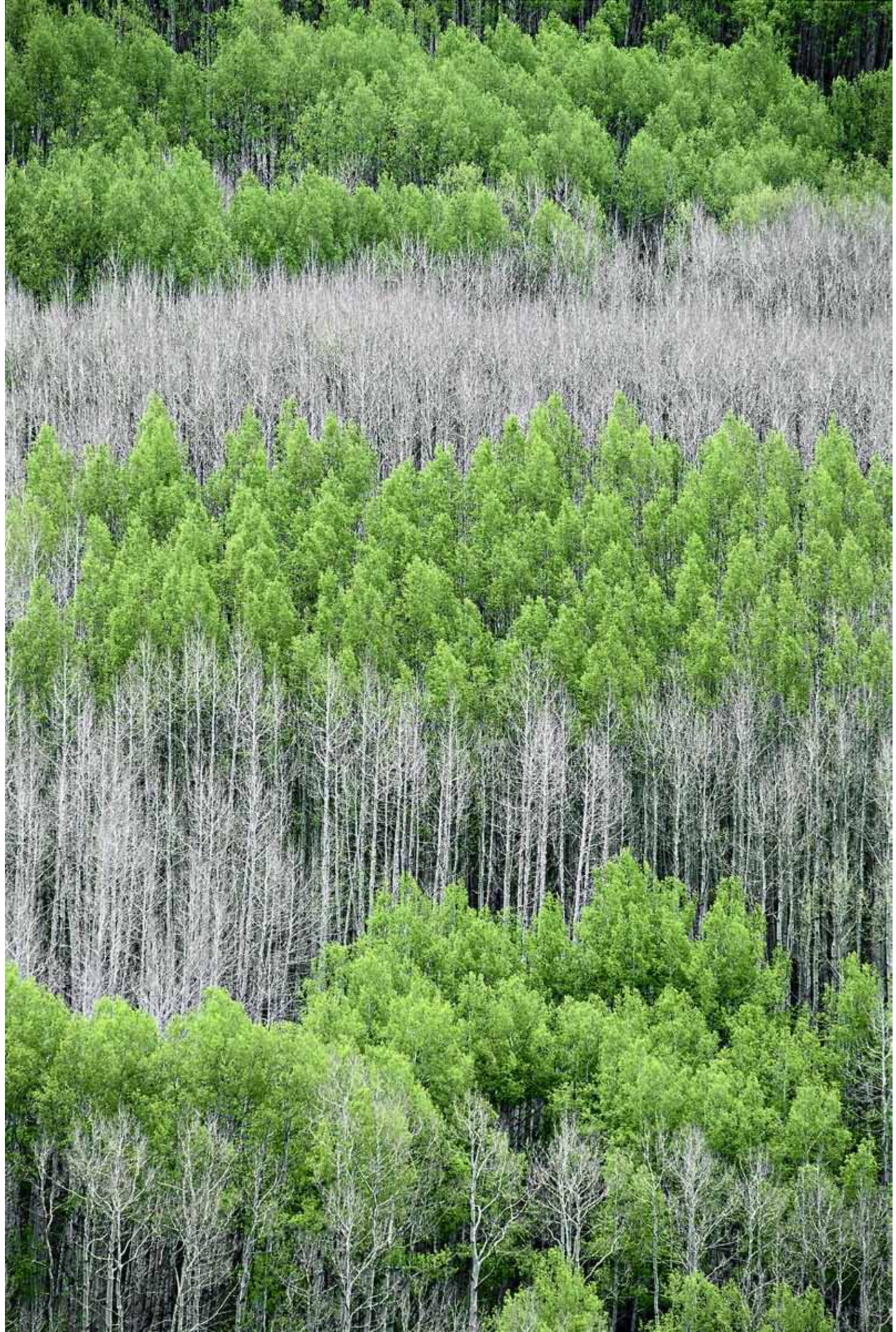
PLATE 27

SOUTH FORK OF THE SAN MIGUEL RIVER

PLATE 28

ALONG THE

DOLORES RIVER



SPRING INTO SUMMER

SPRING'S SHARP GREEN CAN'T HOLD

After the excitement of first leaves, fresh leaves, fresh green, nature exhales, relaxes, refocuses, settles down to the task at hand, growing, growing, grown. Summer is so short in the high country. Sixty frost-free days if we're lucky. Just enough time. Barely enough time. After the confetti of the catkins, the explosion of tiny waxy chartreuse leaves, these forests of light slowly turn into forests of shade, dark even damp. A different green. Dark undergrowth grows up under the pencil-thin pillars of the aspens. Ferns and asters, lupine, cow parsnip, fireweed, sticky geranium. The forest floor comes back to life. The aspen canopy, daily darker and denser, even shelters hikers from afternoon thundershowers. The Rockies throw out the welcome mat, the highest passes open, snowbanks shrink upward toward the summits. In the aspens, the sound of distant rockfall is muffled by leaves, by green. An undersea disguise of green light filtered through green leaves. A rainforest disguise, extravagant, lush and incongruous, in these often arid mountains, under these bare stony peaks.

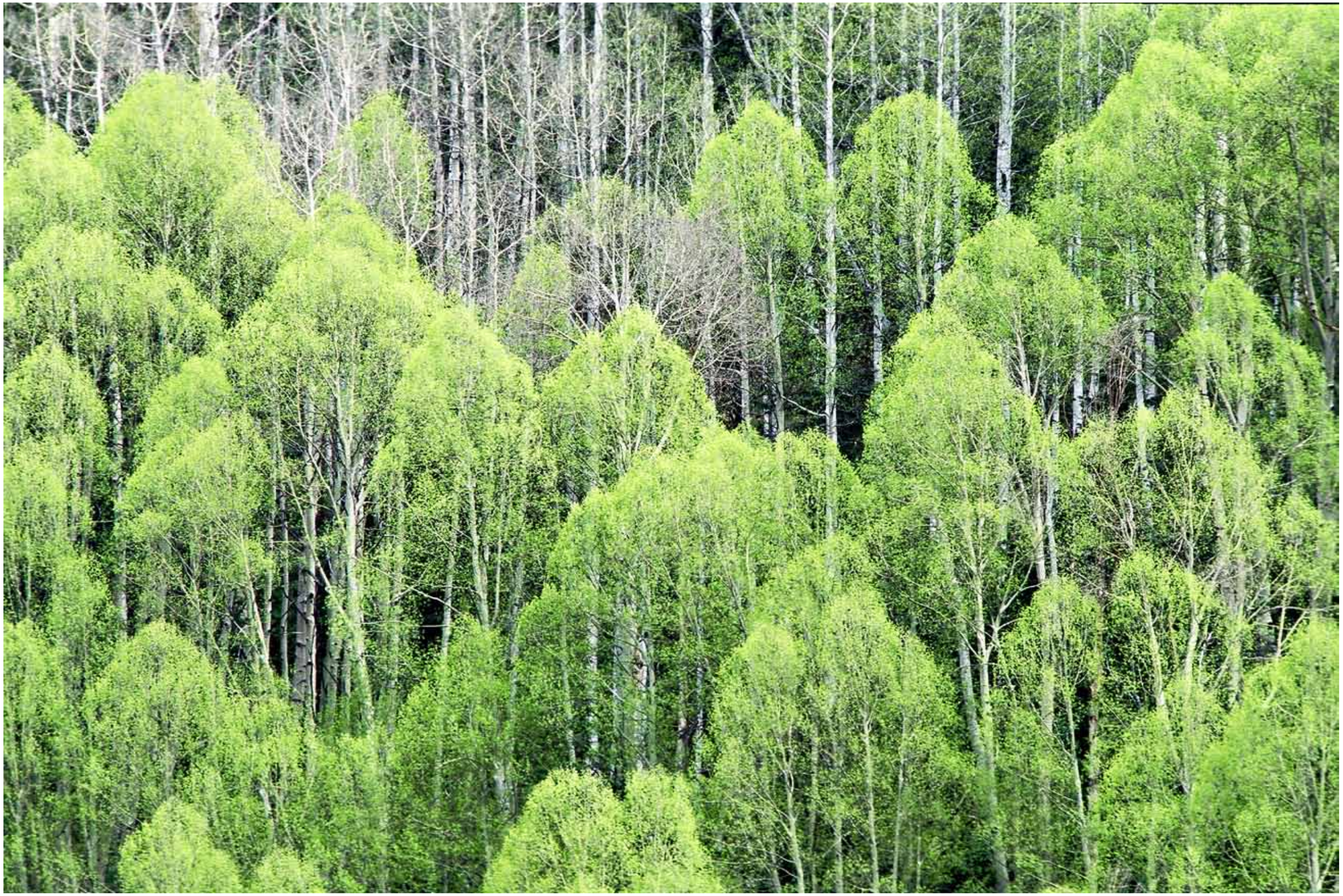
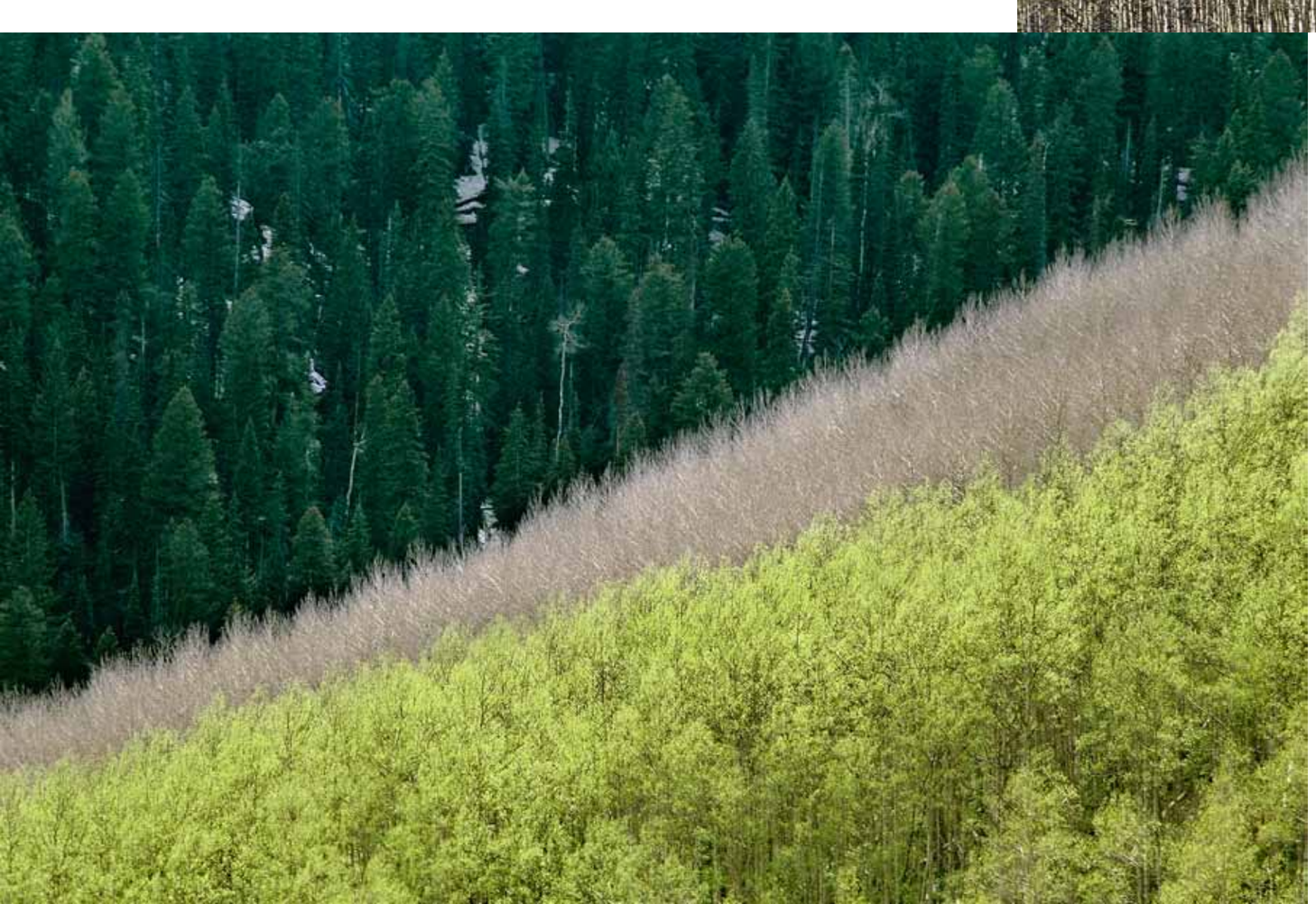


PLATE 29 DOLORES RIVER CANYON

PLATE 30

ALONG THE UPPER DOLORES RIVER



PLATES 31 & 32

NEAR RICO,

SAN JUAN

MOUNTAINS

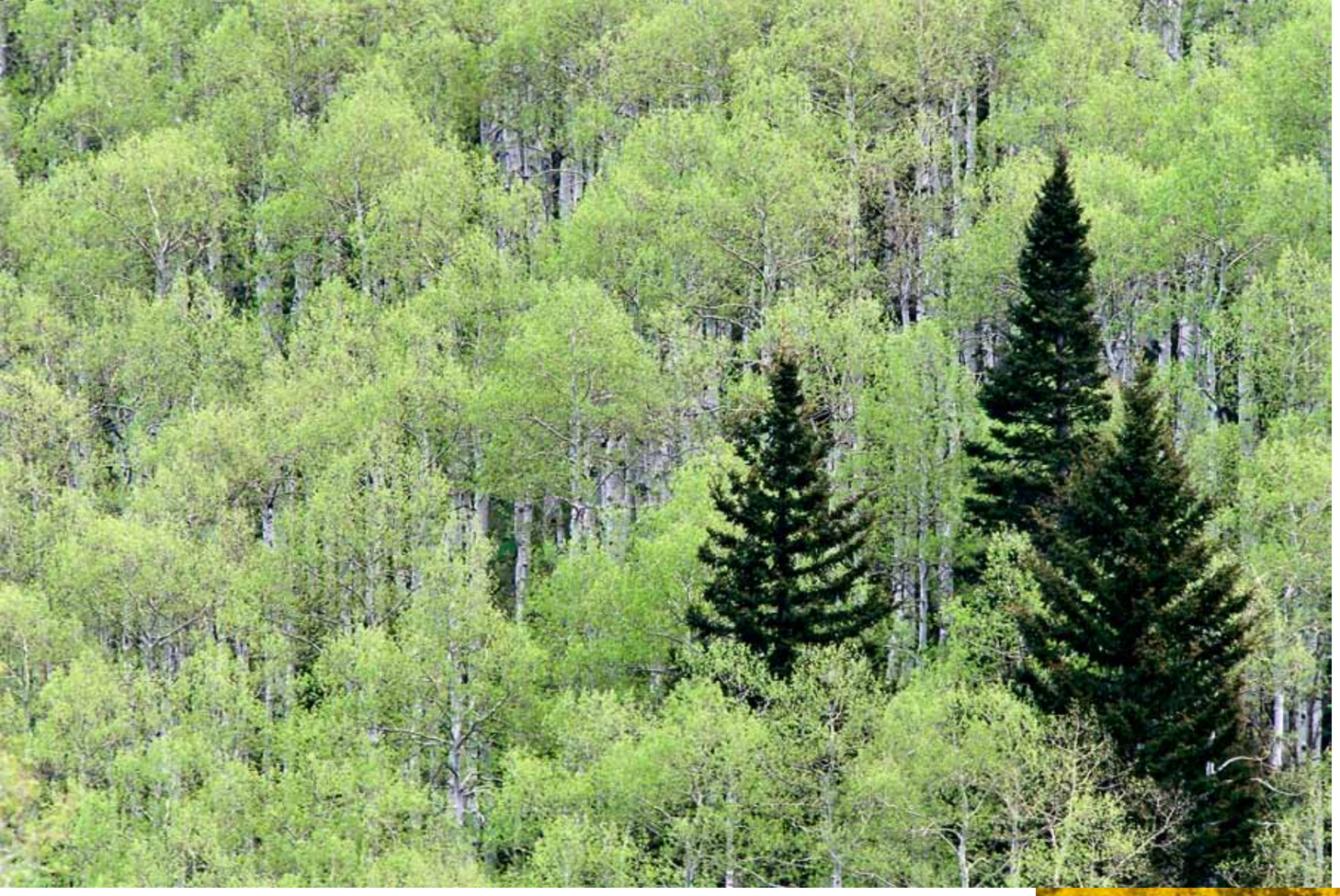


PLATE 33 & 34

DOLORES RIVER CANYON

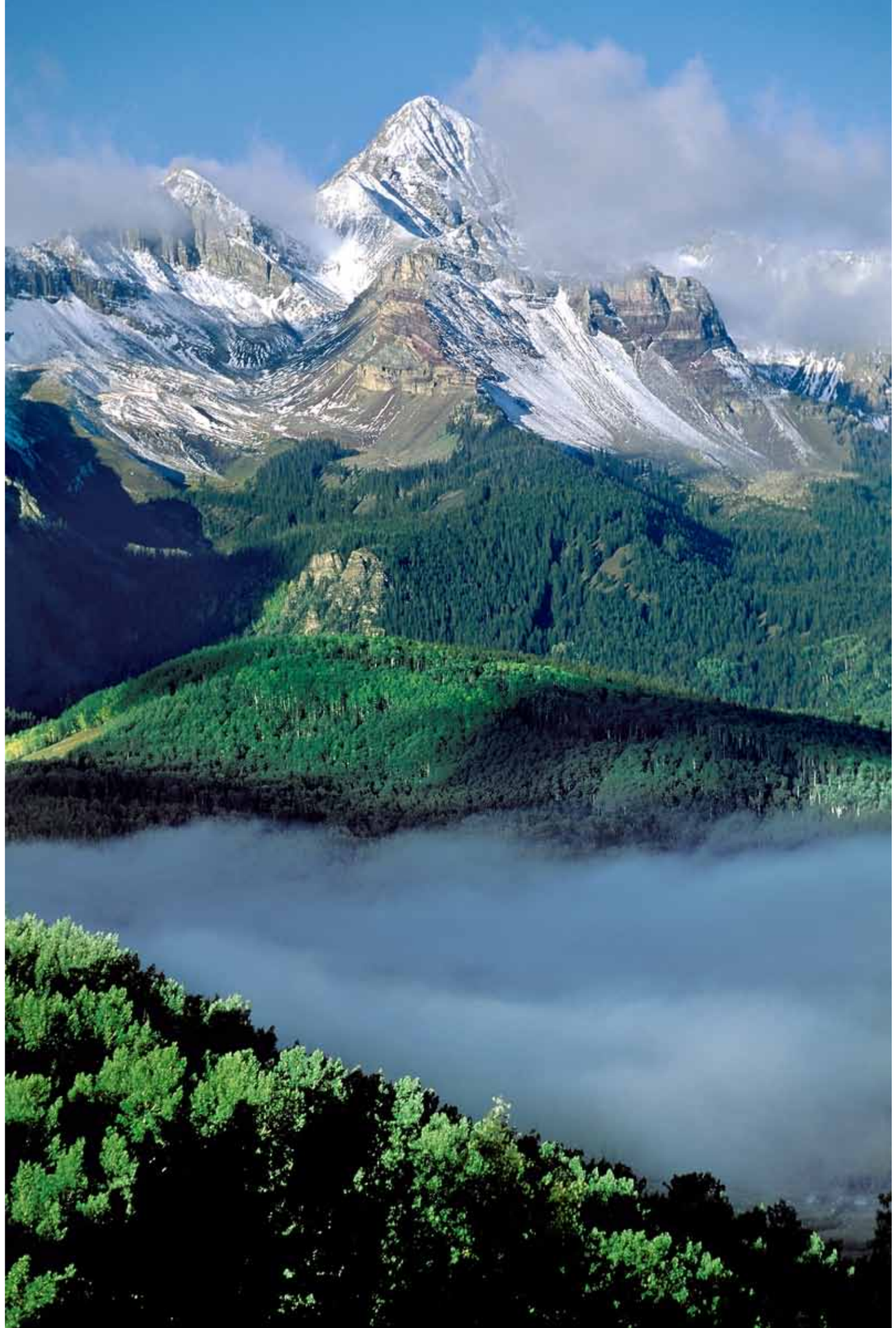


PLATE 35

WILSON PEAK & MESA

PLATE 36

NEAR

MAROON

LAKE

PLATE 37 ON TURKEY CREEK MESA

PLATE 38

ON

WILSON

MESA

PLATE 39 ALONG CASTLE CREEK

PLATE 40

WEST MEADOWS

TURKEY CREEK

MESA

SUMMER INTO AUTUMN

ALL THINGS PASS, SUMMER'S ANOTHER LESSON in impermanence, but what a beautiful lesson. Sliding downhill into fall, falling into an easy trap of color. These trees feel the year start to tip and turn long before we do. Eager leaves jump the gun. Freelance spots of yellow, two weeks, a month too early. Telltale trees telling a tale of winter waiting just out of sight, waiting patiently for autumn's festival to start, then burn itself out, down to the last lost embers in a few lost canyons. The forest turns back through time. Green loosens its grip on the aspens, sneaks off leaf by leaf while the other half of the year sneaks silently back into the forest. Leaves grow paler day by day. August slips away, Rocky Mountain summer folds its tents, empties its trails, sends kids back to school and their parents back to work. You look away for just a moment, and it's already started: autumn's subversive bonfire, autumn's assault on beauty, autumn's heartbreak of astonishment and loss. Autumn among the aspens. We never grow tired of it, we stop and breathe in the color. An old story. A new story. Newly retold.

PLATE 41 SKYLINE RANCH, SAN JUANS

PLATE 42

COSTILLA

NEW MEXICO

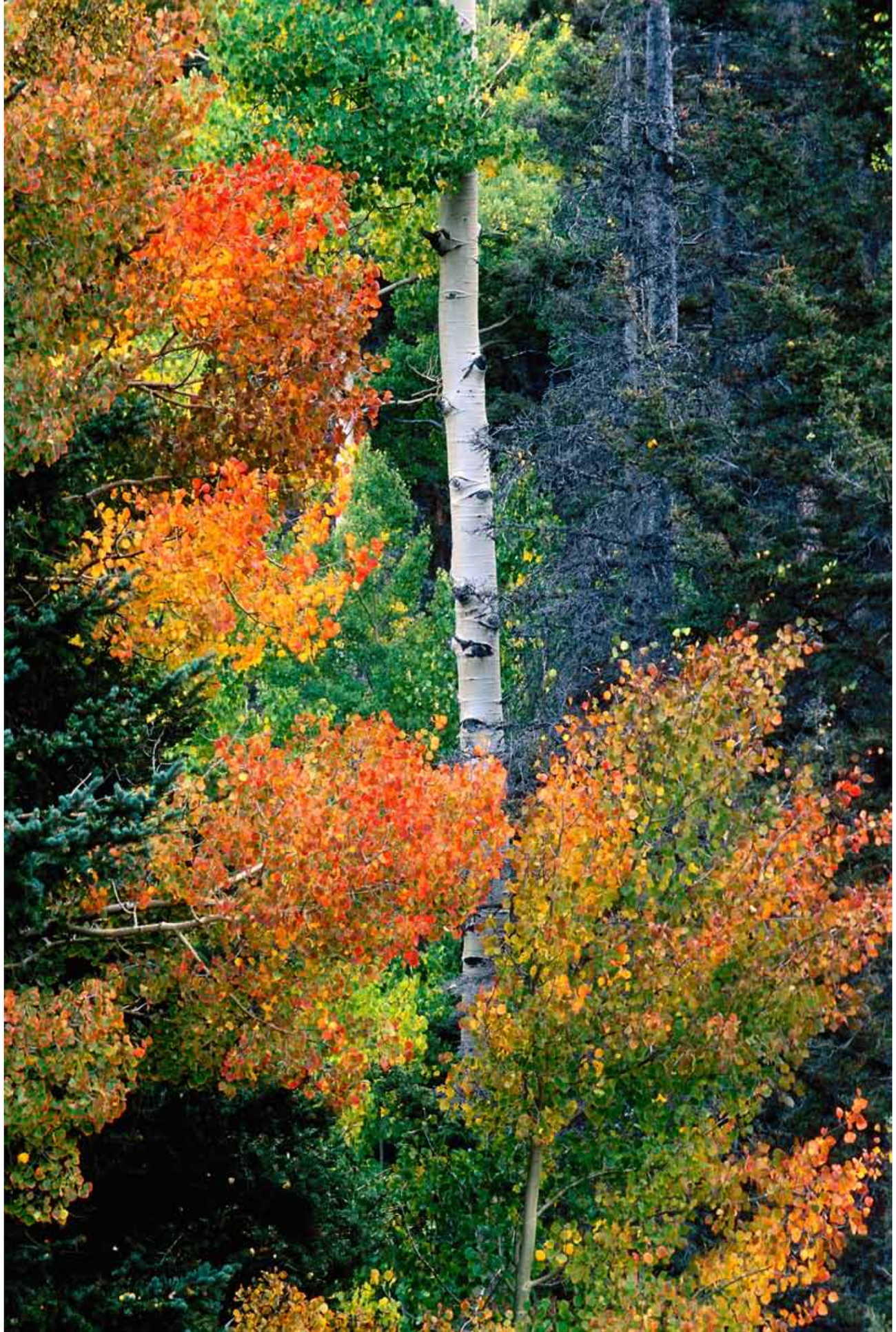


PLATE 43 NEAR TELLURIDE

PLATE 44 BALLARD PEAK, BEAR CREEK

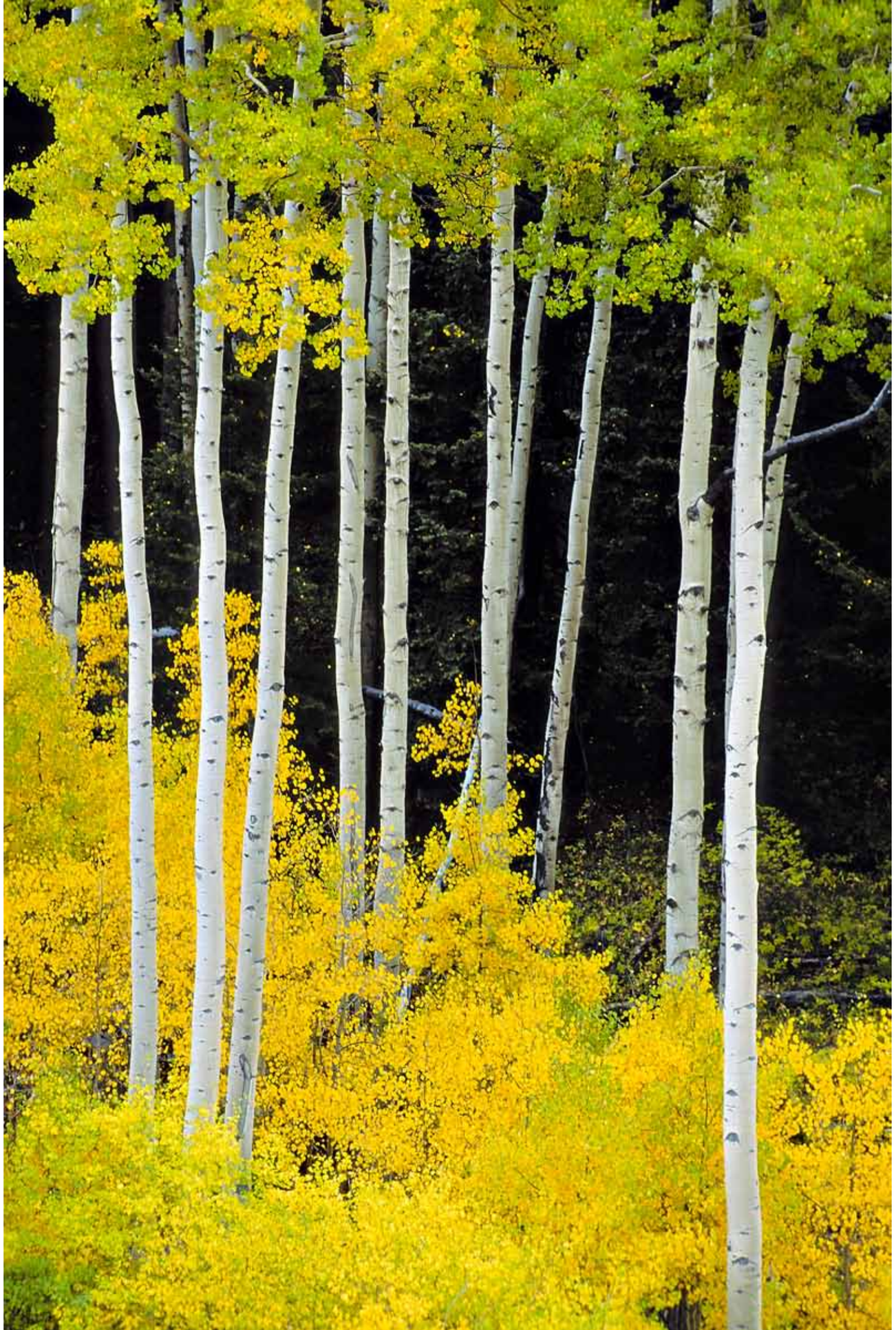


PLATE 45

BELOW

COAL BANK

PASS

PLATE 46

ON

RED MOUNTAIN

PASS

PLATE 47 HOPEWELL PASS, NEW MEXICO

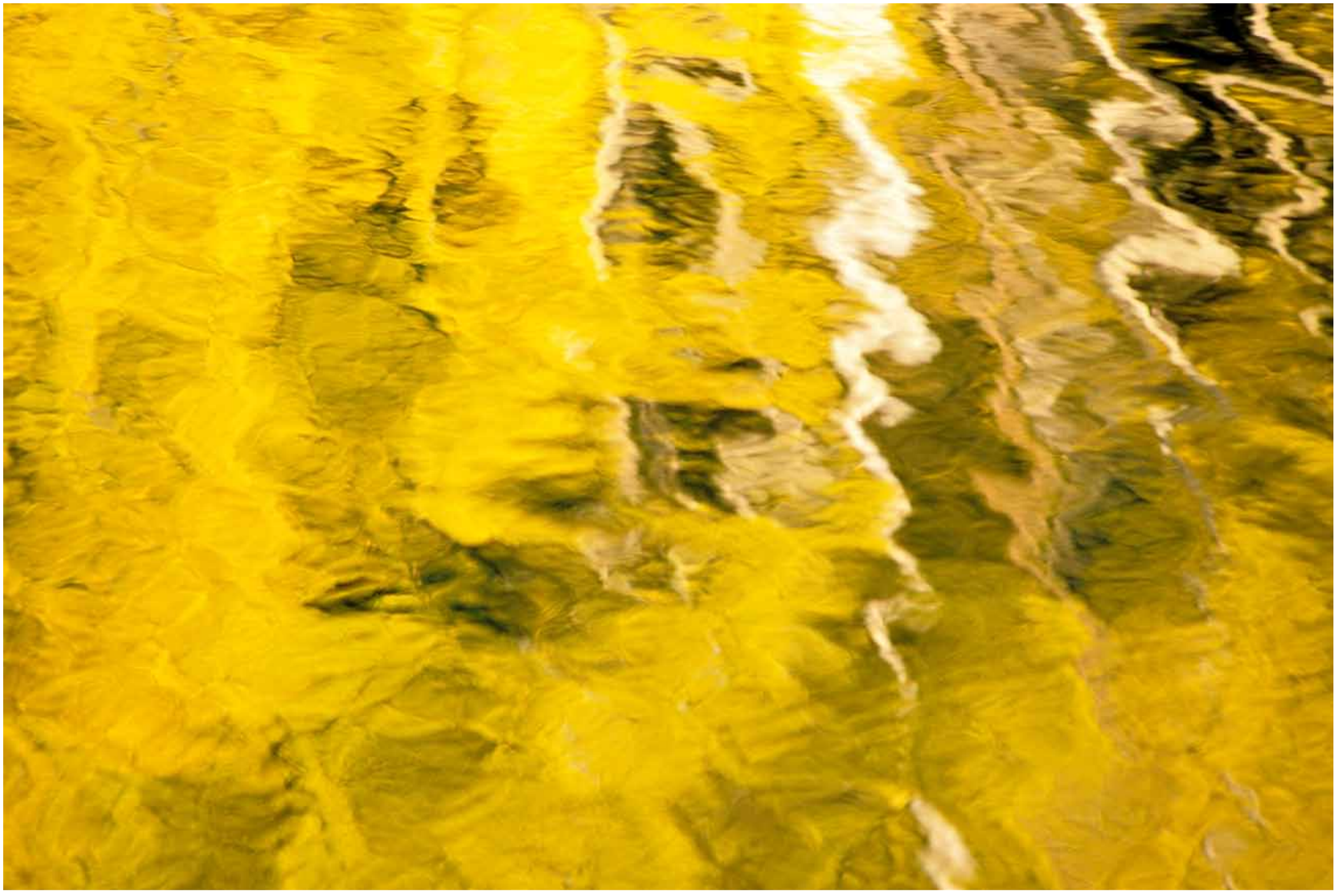


PLATE 48 AT SKYLINE RANCH

PLATE 49

WEST MEADOWS, TURKEY CREEK MESA

PLATE 50

SAN ISABEL CREEK, SANGRE DE CRISTOS

PLATE 51 NEAR IRONTOWN

PLATE 52 CHIMNEY ROCK

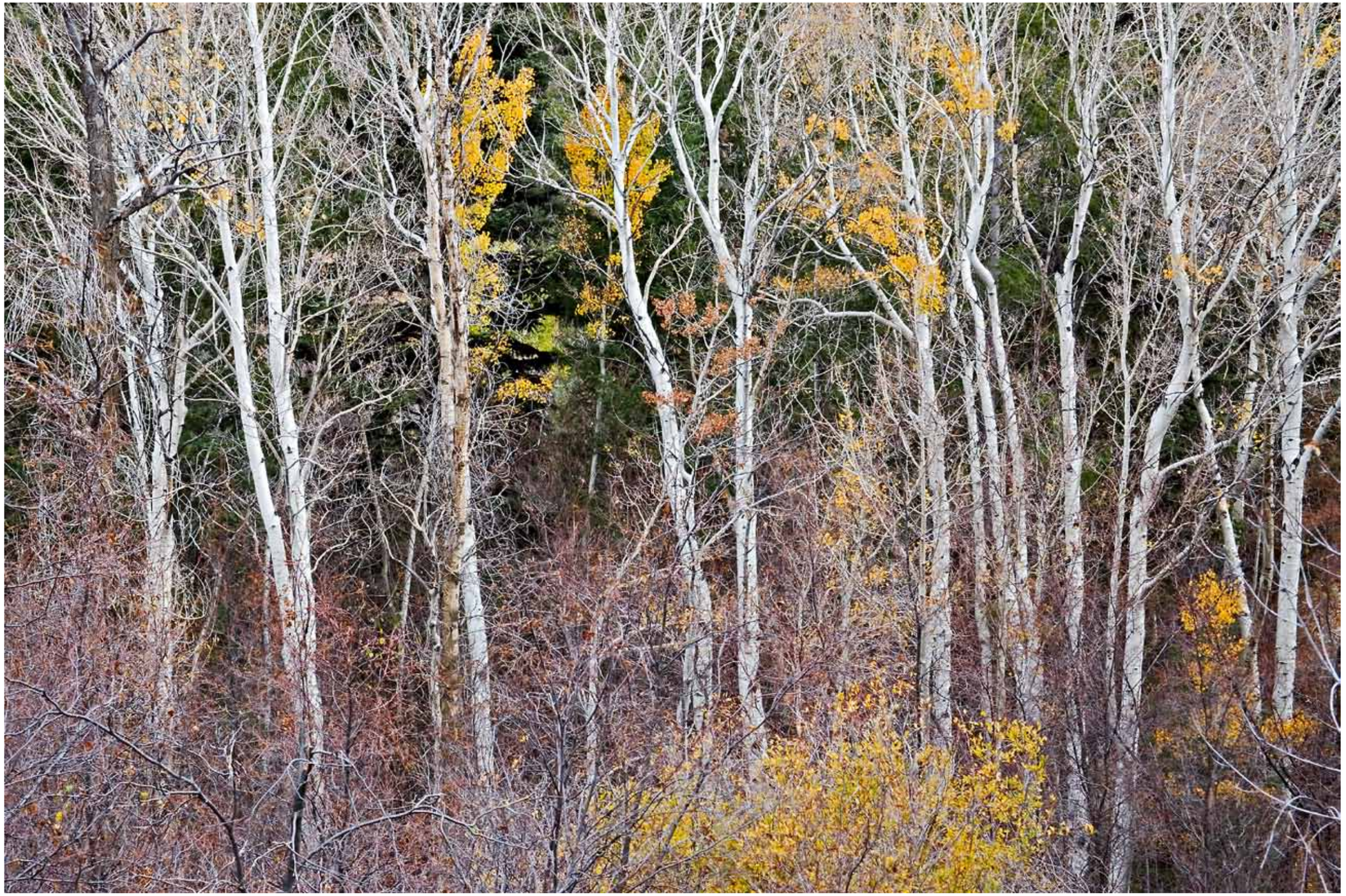


PLATE 53

COTTONWOOD CREEK, SANGRE DE CRISTOS

PLATE 54

SPANISH CREEK, SANGRE DE CRISTOS

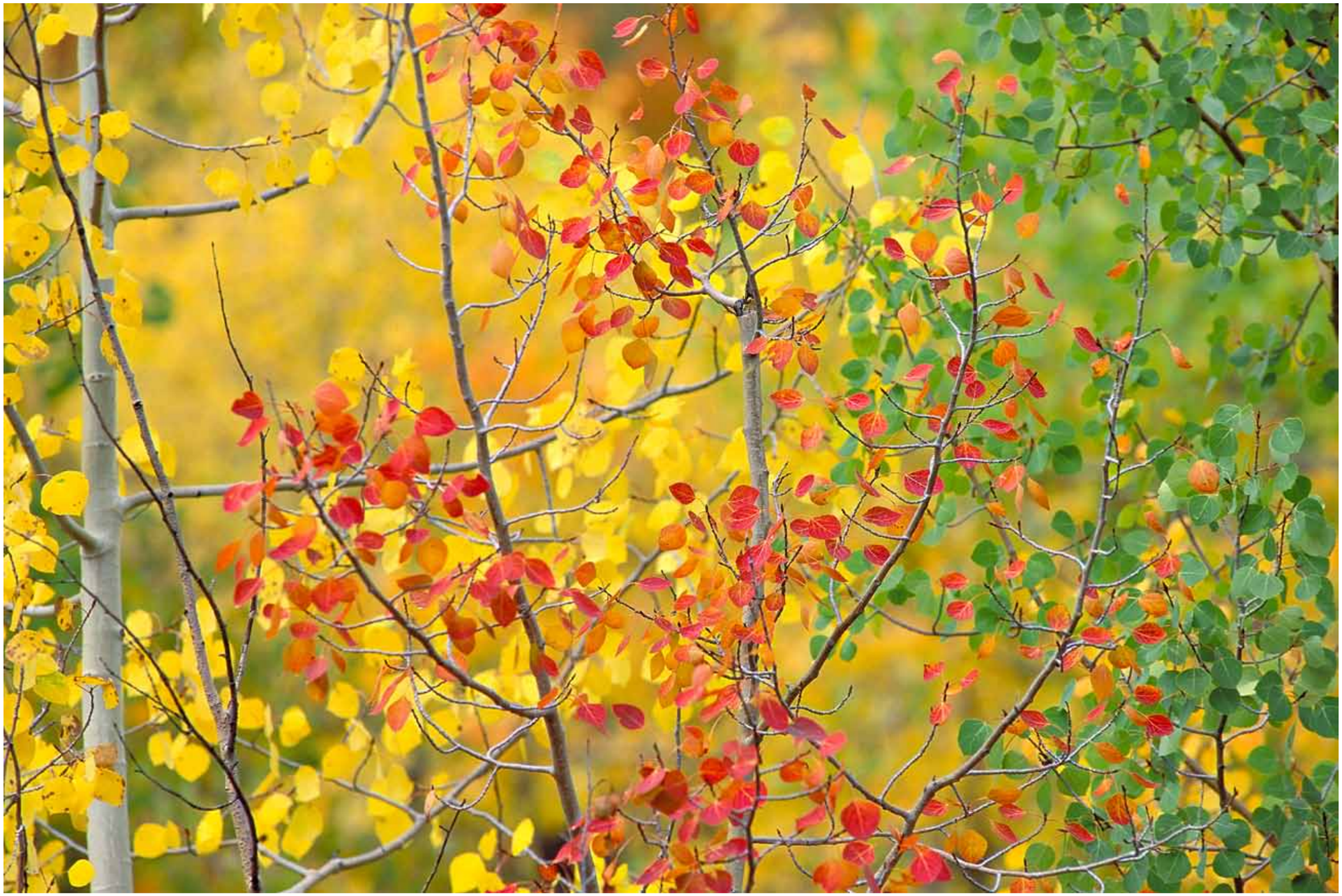


PLATE 55 NEAR RED MOUNTAIN PASS

PLATE 56

SOUTH FORK, SAN MIGUEL RIVER

LEAF DANCE

ASPEN FORESTS OF THE ROCKIES

AUDREY BENEDICT

ASPENS IN THE WEST, the delicate, sparkling green leaves of spring, the matte-green leaves of summer, the golden blazons of autumn, and the leafless, silver-gray trees of winter, mark the passing of the seasons more dramatically than any calendar. In the amber light of late afternoon, on what has become an annual pilgrimage, I climb a ridge above Wild Cherry Creek in the Sangre de Cristos so that I can look down on a "river" of quaking aspen. From my aerie-like perch, the leaves appear impossibly luminous—miniature lanterns powered by distilled sunshine. A puff of wind riffles through the branches, sending a meteor shower of leaves to pattern the forest floor with Spanish dubloons. For a transplanted New Englander like myself, it's probably heresy to admit that I wouldn't trade a single afternoon in a Colorado aspen forest ablaze in shimmering topaz for all the gaudy russet and garnet-red autumns of my childhood. No maple or oak leaf could ever ignite the light in the same way that aspen does—I'm certain of it.

First named by French botanist Andre Michaux in his 1803 Flora Boreali-Americana, quaking aspen (*Populus tremuloides*) needs little introduction. A member of the willow family, quaking aspen is the most widely distributed native tree species in North America and ranks second to the European aspen (*P. tremula*) in worldwide distribution This hardy pioneer is found from sea level on both the Atlantic and Pacific coasts to as high as 11,500 feet in the mountains of Colorado. With a range that extends from Labrador to Tennessee in the East, and from the Arctic

Circle to the Sierra Madre Mountains of Mexico in the West, quaking aspen is no trifling player on the ecological stage. According to a Ute Indian legend, the distinctive quiver of aspen leaves is the result of a visit that Manitou made to earth to view all that He had created. All living things trembled in anticipation of His visit—only the aspen stood tall and still, refusing to pay homage. For it's penance, Manitou decreed that aspen would quake before all eyes, for all time. Many of the common names for this slender, graceful tree—quakies, trembling aspen, popple, trembling poplar, and in Spanish, *alamo blanco* and *alamo temblon*—as well as the Latin epithet *tremuloides*, refer to the tendency of the leaves to flutter and shimmer in the slightest breeze. The color of the leaves—green to blue-green above, and pale, silvery-green below—enhances this effect. In most broadleaved trees, the leaf stalk that attaches the leaf to the twig—the petiole—is round in cross-section. Aspen petioles, in contrast, are long and flattened perpendicular to the blade of the leaf—making the leaf pivot and appear to tremble in the wind. It seems logical that this adaptation provides greater strength and flexibility in windy environments. In a strong wind, aspen leaves tend to align themselves in ways that reduce air drag, the horizontal force that can topple trunks and break off branches. But in a gentle wind, the whisper and chatter of aspen leaves is one of the most treasured sounds in the West.

The quaking aspen of my New England childhood were easily overlooked amid forests dominated by paper birches, sugar maples, and white oaks. Exploring my native landscape, I filled several notebooks with the pressed leaves of every kind of tree I could find, each painstakingly identified in bold black ink and certitude. For a budding naturalist, aspen was just one of the many species to be learned. I had no idea that aspen would one day mark the seasons of my own life—nor any idea that in the West, aspen would inspire legends of its own. For the last thirty years, I've lived at the edge of an aspen grove in the mountains of Colorado and have listened to countless, leaf-whispered stories of adaptation and survival—the beauty, complexity, and continuing mystery of aspen never ceasing to amaze me.

Across the West, the ivory trunks and malachite-green leaves of quaking aspen embolden a forest palette dominated by the somber greens of conifers. Aspen is one of just a handful of deciduous species that thrives in this arid landscape, and can be found in every mountain vegetation zone except alpine tundra. The most extensive and beautiful aspen forests are found at mid-elevations in the mountains of Colorado and Utah, where aspen occurs in small groves interspersed with flower-rich meadows, along cascading streams, as transitional woodlands separating mountain grasslands from coniferous forests, and as scattered individuals or groves in the midst of coniferous forests. In the San Juan Mountains of southwestern Colorado, the setting for many of the images in Forests of Light, aspen forms extensive forests between 8,500 and 10,500 feet. Aspen generally reaches its lower limits in foothill ravines and canyons,

where cooler temperatures prevail and where seepage from higher elevations provides ample moisture. At both it's upper and lower altitudinal limits, quaking aspen is often stunted and gnarled, making the best of the conditions at hand. At timberline, wind-pruned and prostrate, aspen cling tenaciously to any shelter they can find.

Whether growing bonsai-like at timberline in the Colorado Rockies or encircling the water-saturated edges of muskeg and tamarack bogs in the far north—quaking aspen is a remarkable survivor. It's broad altitudinal and ecological range suggests that aspen has found ways to cope with adversity. Though it tolerates cold temperatures and late-lying snow, aspen cannot withstand high summer temperatures (in excess of 90°F) or prolonged drought. It thrives in areas that receive more than 25 inches of precipitation a year, but will hold its own with far less. In the Rockies, large-scale air movements and precipitation patterns deliver prodigious amounts of moisture to windward slopes west of the Continental Divide, creating perfect growing conditions for quaking aspen. On Colorado's Western Slope, the longer growing season and the summer rains associated with the Arizona monsoon provide the most likely explanation for the majestic proportions of aspen in the Flattops, West Elk, and San Juan Mountains.

Summers in these aspen forests, with their hip-high profusion of wildflowers and bracken fern, have an almost tropical quality. Wading through the lush undergrowth of a favorite grove, the branches conjoined high overhead to form a cathedral-like ceiling, I have no doubts about the sacredness of such places. Shafts of sunlight gild the finely pleated leaves of corn lilies, the white-topped umbels of cow parsnip, and the tall, magenta-colored spikes of fireweed. Along the sunnier edges of the grove, blue columbine, monkshood, and showy daisies grow as rankly as those in any English cottage garden. The forest looks completely different in early spring, when snowmelt rivulets nurture a carpet of avalanche lilies, spring beauties, and chiming bells. A long succession of Basque and Mexican sheepherders have trailed their sheep through these verdant groves, their intricate and occasionally erotic carvings on aspen trunks a legacy of gentler times. I'll never forget my first glimpse of a sheepherder's wagon nestled in a tranquil grove in the Flattops, the top of the Dutch door open to greet the day, the interior painted the same blue as the sky. The herder's horse was tied to an aspen that displayed the most remarkable bark carving I'd ever seen—a depiction of a graceful branch of aspen leaves, each leaf edged with tiny lines meant to convey the dance and shimmer of the leaves, the carver's signature and date proudly inscribed below. Though I lacked the temerity to interrupt the sheepherder's solitude, the evocative image he captured with a few simple knife strokes remains etched in my memory. Sadly, the lifespan of an aspen tree rarely exceeds a hundred years, the graying skeletons of fallen aspen forming a fretwork amid the lupine and wild rose. I can only imagine the generations of aspen folk art—expressions of beauty

and loneliness, painstakingly carved in bark—that have been lost to the moldering leaf litter on the forest floor.

The discovery of fossil leaves similar to those of modern quaking aspen suggests that aspen have flourished throughout western North America for the last 15 million years, since middle Miocene time. By all accounts, quaking aspen is a species whose modern distribution is shaped by fire and ice. The advance and retreat of the Laurentide and Cordilleran ice sheets during the Pleistocene is believed to be responsible for the present-day distribution of quaking aspen. The relentless advance of alpine and continental glaciers pushed tundra and boreal forest ecosystems south into what is now the United States and northern Mexico. Once the glaciers retreated, patches of quaking aspen persisted wherever cool, moist conditions prevailed and where sunny, newly-exposed seedbeds provided optimal conditions for germination and growth. With the onset of warmer and drier conditions during the Holocene, the incidence of forest fires—both lightening and human-caused—increased dramatically across the West. The ecological stage was set for any species that could adapt its reproductive strategies to withstand the catastrophic impact of fire. Quaking aspen and another aggressive pioneer, lodgepole pine (*Pinus contorta*), would be the first to exploit this new niche, each adopting a vastly different strategy for survival.

Quaking aspen's adaptation to fire lies buried beneath several inches of soil. In the aftermath of any disturbance that removes or damages the existing forest cover—fire, avalanching, wind-throw, beaver cutting, girdling, disease, defoliation, or logging—aspen roots have the capacity to become instant sprout factories. Each lateral root may contain thousands of budding sites, up to 600 per 18-inch section of root. It is not uncommon for the lateral root system of the "parent" tree to have spread out for 100 feet or more. The sprouting, or suckering, potential of an aspen root system is astronomical. Wayne Shepperd, an aspen ecologist with the U.S. Forest Service, estimated close to a million aspen suckers per acre in one regenerating stand in Colorado. What triggers such fecundity? Auxin, a growth-regulating hormone, is continually being produced in the crown of an aspen tree and shunted to the roots, where it serves to inhibit suckering. When the crown is destroyed or damaged, auxin flow to the roots stops. Cytokinin, a growth-stimulating hormone synthesized in the tips of the roots, quickly dominates the hormonal equation. Once the hormonal balance shifts, suckers proliferate at previously dormant budding sites along the lateral roots. The new suckers are completely dependent on the parental root system for nutrients and water, with the degree of dependency diminishing gradually as the sucker develops its own root system. Studies suggest that aspen suckers grow very rapidly, and that some may become independent of their parental root system by the end of their first growing season. In fact, most aspen suckers will have established independent root systems by

approximately 25 years of age.

Cloning is a word we've come to associate with white-coated lab technicians working furtively behind closed doors—for good or evil, as the case may be. Yet, as any gardener knows, vegetative reproduction—cloning—happens all around us. In the case of quaking aspen, the word clone is used to describe an aggregation of aspen stems that have arisen as a result of suckering from the lateral root system of a single, seedling-grown parent tree. The parent tree is referred to as the ortet and each of the suckers is called a ramet. Barring rare mutations, all ramets in a given clone are genetically identical to the ortet and will exhibit the same genetically determined characteristics, or genotype, as the ortet. Members of one aspen clone may differ from others on the basis of genetic traits such as growth form, branching habit, bark color, leaf form, leaf color, seasonal phenology (timing of leaf emergence and leaf drop), and susceptibility to insect, disease, and frost damage—each trait intricately woven into the forest fabric.

For me, the surest sign of spring in the mountains is the swelling of aspen leaf buds and the rosy haze that envelops the crowns of the still-leafless trees—the result of millions of aspen flowers dangling from the branches. The life history of quaking aspen challenges our understanding of Darwinian evolution—a theory whose central theme of natural selection is based almost solely on sexual reproduction. Most tree species depend on sexual reproduction—producing seeds that germinate and give rise to new individuals with the same genotype as the parent tree. In some species, a single tree will have both male and female flowers on the same tree. In others, such as quaking aspen, male and female flowers are borne on separate trees. The male (pollen-producing) and female (seed-producing) flowers of quaking aspen are called catkins, and emerge just before the leaves unfurl. The male catkins, with their crimson stamens, are stunningly beautiful when viewed through a hand lens. After their pollen is shed, male catkins wither and fall from the tree. Once pollinated, the larger and somewhat pendulous female catkins grow to a length of about 4 inches, the apetalous flowers swelling to form strings of shiny green capsules. At maturity, which occurs about 4 to 6 weeks after flowering, the capsules burst, releasing a multitude of minute seeds cloaked in long, silky hairs, perfectly adapted for transport by wind or water. Like other members of the willow family, quaking aspen is a prolific producer of viable seeds—the standard currency of sexual reproduction. One 23-year-old aspen in western Colorado is estimated to have produced 1.6 million seeds during a single season!

Though millions of aspen seeds are produced, successful germination and seedling survival is a rare event in the West—the exception rather than the rule. Seedling success requires a persistently moist seedbed, soil temperatures that are warm but not too hot, and soil that is well drained, loamy, and high in nutrients. The seedbed must be free of destructive soil fungi and have no surface litter to snuff out the light for the sun-

loving seedlings. The roots of aspen seedlings grow very slowly for the first few days, the young plant depending exclusively upon a brush of fine hairs to take up water and nutrients and to anchor the seedling to the seedbed. Any drying in the uppermost soil layer can quickly spell death for the tiny seedling. In the West, drying out of the seedbed is the most common cause of seedling mortality. Though a certain number of seedlings can usually be found in areas where fires have occurred, in garden plots, and in clear cuts, seedling survival is tenuous at best. In fact, in one especially grim scenario for western aspen, researchers propose that conditions favoring widespread seedling establishment may happen only once every 200 to 400 years.

The ability to reproduce asexually—by cloning—is clearly the key to quaking aspen's success across a broad range of changing, and sometimes hostile environments. From the very moment of sprouting, an aspen sucker has a competitive advantage over a seed-grown plant because of the built-in support system provided by the parent tree. Only persistently water-logged soils or severe drought can inhibit sucker production in the aftermath of disturbance. The shape of an aspen clone reflects the conditions under which the clone was established. The abundance of light along the leading edge of an expanding clone enhances the survival and proliferation of new ramets, resulting in the development of a somewhat symmetrical, island-like stand. Clones of this type often have a "fairy ring" of younger trees around the edges and are especially common in high mountain basins such as South, Middle, and North Parks. High soil temperatures are also known to degrade auxin and to encourage the production of cytokinin, which may to help to explain aspen's success in invading grasslands and sites where disturbance phenomena have removed the pre-existing cover. Still other clones have a distinctly stair-stepped appearance due to successive stages of regeneration. Through expansion of the ramet root system and additional suckering, a clone may proliferate over time to cover a hundred acres or more. Clone size is primarily a function of clone age, the number of seedlings initially established, and the frequency and degree of disturbance since seedling establishment. Geneticist Michael Grant and his colleagues at the University of Colorado identified and named the largest known aspen clone in North America—the 106-acre, 47,000-stem Pando clone, located in Utah's Fish Creek National Forest. Based on their own research, Wayne Shepperd and his colleagues suggest that a single aspen seedling could spread to a clone the size of Pando in only a few hundred years provided that sucker events occurred more than once per generation—and especially if frequent ground fires stimulated sucker development. One consequence of fire suppression has been the drastic reduction in the extent of aspen forests throughout the West. In the absence of fire or other sources of disturbance, the natural trend is for conifers to invade aspen forests, gradually overtopping and shading out the younger aspen trees. Aspen clones that consist only of mature

trees, with no sign of suckering to replace the trees that die, are very likely doomed. In many such cases, persistent heavy browsing on the new shoots by wild or domestic grazing animals has reduced clonal vigor to such a degree that the clone may eventually disappear.

Looking down on the aspen forest in Wild Cherry Canyon, I'm fascinated by the autumn color pattern that I see—a simple lesson in using color differences to identify individual clones. The typical aspen forest may consist of a single clone or a mosaic of clones, each exhibiting a unique genotypic signature. Distinguishing between individual aspen clones is especially easy in autumn, when genetically determined characteristics such as leaf color, the timing of color change, and the timing of leaf shed are readily apparent. At Wild Cherry, clonal boundaries are especially dramatic—a saffron-yellow grove gives way to one dressed in apricot and cinnabar, a grove still cloaked in summer-green provides a striking counterpoint to one already leafless. If I were to return to Wild Cherry in spring, I would see similarly striking differences from clone to clone signaling the end of winter dormancy and the beginning of flowering and leaf emergence. In fact, leafing time between clones can vary up to a month, depending on each clone's predetermined response to temperature and light cues. Aspen clones in first-flush green form a stunning mosaic when intermixed with clones still leafless and stark, held tight by winter's grasp. Leaf shape and size, the amount of serration along leaf margins, and the hairiness of the dormant leaf buds are other clone-specific traits that make it easy to distinguish one clone from another. Additionally, the trees in a given clone are usually either all male or all female. In Colorado, male clones tend to be more common at high elevations and female clones more common at low elevations. Though uncommon, a few trees in a clone may have catkins of both sexes present on the same tree. Just when you think you have quaking aspen all figured out, it changes the rules.

Throughout the seasons, aspen clones reveal their genetic makeup and vulnerabilities in myriad ways. Against a backdrop of stolid conifers, a grove of tall, tufted aspen has the graceful bearing of a herd of giraffes. A clone made up of straight, even-aged trees may look as conservative as a picket fence. Just a short distance away, the trunks in another clone seem to chronicle a life of hardships, quirking this way and that with passionate abandon. Some clones seem interwoven with branches and twigs, some have branches that angle sharply skyward, while others have branches arranged in orderly ranks, perpendicular to the trunk. Where many branches have fallen as a result of self-pruning, an abundance of charcoal-hued branch scars, like so many watchful eyes, gives the clone a curiously animate quality. Even the color of aspen bark, ranging from pearl white and oyster to dove gray and olive green, is linked to aspen's survival strategy. Aspen is unique among northern trees in having smooth greenish bark that is capable of photosynthesis. A whitish layer of cells—the periderm—overlies the green and forms a powder-like, protective

layer so thin that you can scrape it off with a fingernail. In winter, high altitude sunlight can cause extensive sunscald damage to unprotected trees, especially those at the outer edge of a grove. Whiter periderm tissues mean higher reflectance levels and reduced vulnerability to heat damage as well as to the temperature fluctuations that can cause cell breakage in the sap-conducting tissues, or cambium.

In many ways, aspen is a fragile species, beleaguered by problems. Each clone has its own genetic predisposition to insect attack, disease resistance, frost damage, and the ravages of aging. Not long ago, in the Yukon, I marveled at the serpentine meander patterns that aspen-leaf miners had made as they ate their way through the sandwich of cells that lies between the upper and lower cuticle of the leaf. Most of the leaves in one clone seemed to be infested with these miniscule moth larvae, while an adjacent clone appeared to have escaped the infestation altogether. Differences in leaf chemistry apparently make some clones more vulnerable to insect attack, while others seem imbued with a chemical shield against infestation. Some clones also seem particularly susceptible to fungal diseases, a fact that cavity-nesting birds exploit when locating suitable trees in which to excavate nesting holes. By following the rhythmic drumming sounds made by a red-napped sapsucker, I once found myself in a grove of large aspen that seemed to be losing the battle with disease of one sort or another. On closer examination, I could see that nearly every tree had a hoof-shaped conk shelving out from beneath a branch scar. These distinctive conks are actually the fruiting bodies of white heart rot (*Fomes igniarius*), a deadly fungal infection that invades the heartwood and then spreads outward to kill the cambium. Wounds caused by fire scars, insect entry or exit holes, fresh branch scars, bark carving, or browsing animals all provide easy entry for fungal spores. In some cases, a shiny, rust-colored ooze drips down the trunk, pinpointing the possible entry point for infection. But even decay has a silver lining; aspen forests are one of the most bird-rich habitats in the West. By tapping on infected aspen trees, sapsuckers, woodpeckers, and flickers are able to locate—by sound—disease-weakened wood that will simplify cavity excavation. After a single season of use by the cavity excavator, the ready-made housing provides suitable cavities for a rich diversity of other species that are unable to excavate their own nest holes—flammulated owls, northern saw-whet owls, and northern pygmy owls, mountain bluebirds, mountain and black-capped chickadees, house wrens, tree and violet-green swallows, brown creepers, pygmy and white-breasted nuthatches, and many more.

With September's arrival, the vibrant green of summer aspen dissolves in a blaze of golden light. Green is the color of photosynthesis—the sun-powered plant engine that drives all life on earth. Chlorophyll, the green pigment that gives plants their green color, is encapsulated in minute sacs, called chloroplasts, that are located in the cells of leaf and stem

tissues. Chlorophyll absorbs light energy from the sun and then transfers it to reaction centers in the chloroplasts. The chloroplasts then transform water and carbon dioxide into high-energy carbohydrates such as sugars, starches, and cellulose. The chlorophyll in aspen bark allows the tree to photosynthesize almost year-round, even at temperatures below freezing—a distinct advantage when leaf carbohydrate production is severely reduced as a result of a late spring freeze or insect defoliation. The high-energy food produced by photosynthesis is stored in various ways, such as in swollen roots and stems, and is used to fuel growth. Animals, of course, acquire the energy produced by photosynthesis by eating plants, or by eating plant-eaters, and so on down the line.

During the spring and summer, aspen leaves serve as the primary factories for photosynthesis. In addition to chlorophyll, aspen leaves contain three pigments that, in differing gene-based combinations, produce the colors that define the chromatic amplitude of a Rocky Mountain autumn: the purest yellow is produced by the pigment xanthophyll, gold and orange hues come from carotene, and the rarer reds are the result of anthocyanin. These pigments are almost completely masked by chlorophyll during much of the year. The coloring process begins in late summer and early autumn when shorter days prompt the trees to stop food production and to begin withdrawing sap into their trunks and roots for the coming winter. The circulation to the leaves is cut off, the chlorophyll in the leaves breaks down, the green color disappears, and the vivid hues of the other pigments move to center stage. Crisp, sunny days and cool nights when temperatures drop below 45°F (but not below freezing) are necessary to bring about the most spectacular displays of autumn color. These conditions inhibit the withdrawal of sugars from the leaf, a situation that favors the accumulation of pigments. If the weather is cloudy and rainy or if there is an early killing frost, the colors will not be as vibrant and the leaves may turn drab and sere. The color grows in intensity at the higher elevations first, spreading like a firestorm to burnish the foothills below. While all these changes are taking place, a hormone at the base of the aspen leaf is working to weaken the link between leaf and branch, producing a separation layer. Once this process is complete, the leaf will be ready to separate from the tree with the first fretting breeze. For those of us who love aspen, the time is bittersweet—the soft rustling of the leaves will soon be replaced by the sweet, tannin-rich perfume of aspen leaves gone to earth. The final dance of the leaves is over for another season.

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FORESTS OF LIGHT

is published by Western Eye Press

Box1008, Sedona AZ 86339

telephone 1 800 333 5178

www.WesternEye.com

This electronic edition or eBook was produced in 2010,

and has been optimized for viewing on the iPad as well

as on any computer display, ideally with Adobe Reader.

Forests of Light is also available as a limited edition

large-format art book, and a standard hardback edition.

This book was designed by Lito Tejada-Flores

All the photos in this book are available as state-of-the-art

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