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Butterfly Conservation Management in Midwestern Open Habitats

Part 4: How do I recommend proceeding forward?
by Ann B. Swengel

Summary. Instead of focusing on what we should or shouldn't blame on management with regard to butterflies (what's bad), I want to focus instead on what's been found to work better for butterflies that need conservation help (what's good). Both management consistency *within* site and diversity of management *among* different sites *of the same vegetative type* are good practices because specialist butterflies have rather narrow habitat and management tolerances, but each specialist has its own optimal management preference and these differ among specialist butterflies. I advise at least 50% of resources go toward data collection, with the remainder toward management. I do not recommend burning for butterfly conservation in the Midwest, even if done in rotation. But if fire management occurs in a site, the most beneficial step is to maintain a never-burned area in core habitat for specialist butterflies, with unintensive consistent alternative management as needed to control brush and weeds and maintain adequate caterpillar resources. Mowing (mechanical cutting that leaves the cut vegetation to lie in place) and haying (mowing with removal of the cut vegetation) are more favorable for more midwestern butterfly species than burning. However, mowing and/or haying, or certain kinds of them, are not favorable for all specialist butterflies in the same vegetation type. Such management should be done in rotation, not treating the entire site at once in a year, in fact not treating all of a particular vegetation *type* at once in a year. Other management options include grazing, localized treatments (brush-cutting, spot-herbiciding), timber harvest, and even idling (no management) while more study is done.

There is no one-size-fits-all answer for managing a vegetation type or a butterfly species. Consider human medicine. You expect your medical practitioners to study lots and lots of research, not just a few anecdotes that seem similar to the anecdote that is you. But you also expect your doctor to individualize all this knowledge to your specific set of advantages and disadvantages from your medical history, and your preferences. Furthermore, you expect your practitioners to maintain ongoing monitoring to assess your condition and the effects of any treatment or choice to opt for no treatment. You expect them to adjust and improve your care based on that monitoring and on new research findings that they work to keep up on too. As with your health, so also with habitat management, I advise proceeding based on what's known with caution for what's not yet known, while monitoring the site condition and butterfly populations and watching for new developments in science that may apply to your situation.

Instead of focusing on what we should or shouldn't blame on management with regard to butterflies (what's bad), I want to focus instead on what's been found to work better for butterflies that need conservation help (what's good). Important as it is to understand why butterflies are declining, and management is a component of that, that isn't enough to get good butterfly outcomes. My focus isn't on whether fire or grazing has been proven to be natural or harmful. It's possible to eliminate all that's proven to be harmful and still not get a good outcome. It can be hard to prove that something is harmful even when it is, plus eliminating bad things isn't sufficient. It's also necessary to get all the good things to go right consistently and sufficiently enough. From my point of view, that's even harder to make happen. But this is definitely possible, as proven by others, such as my revered British colleagues who learned from extirpation of the Large Blue sufficiently to succeed at reintroducing it back. I feel it's also proven right here in Wisconsin. Scott Swengel and I have been thrilled to demonstrate statistically that some populations of some rare butterflies, like Frosted Elfin, 'Karner' Melissa Blue, Regal Fritillary, and Mottled Duskywing, had stable or increasing patterns. We've also documented relatively better outcomes for specialist butterfly populations experiencing management planned and executed to be species-specific, compared to other populations receiving general ecosystem conservation.

So my approach is not whether a certain general approach (burning or mowing or grazing or doing nothing) is OK, or OK enough, to avoid blame. Instead, I want to focus on what factors most appear to be most helpful in retaining biodiversity in need of conservation. How do you prioritize? How do you deal with unknowns? What are you trying to accomplish? What are the conflicts and tradeoffs? What are realistic expectations?

What most helps to conserve rare butterflies are site selection and management based on detailed knowledge of the butterfly's biology in all its life stages and consistent adequate long-term population monitoring. Specific knowledge of a species' requirements in all its life stages is necessary to ensure that required resources (food, microclimate, shelter, etc.), especially in the caterpillar life stage, are consistently available in the condition and volume needed. Furthermore, enough of the butterflies themselves need to exist consistently in adequate numbers to maintain a viable population. This approach has the strongest scientific backing because it understands the "mechanics" of the interaction of habitat and management with the butterfly at the

level of cause-and-effect. This is what our British colleagues have achieved with the Large Blue.

Even with detailed knowledge, though, it may not be possible to avoid difficulties in accomplishing effective conservation. Knowledge without the will or ability to apply it can't help a butterfly. Choosing to optimize habitat for one species (e.g., clearing brush to increase area of open habitat) can mean reducing resources required by another species, whether deliberately or inadvertently. There are always going to be species, both plant and animal, that are more popular and well known, and others not so much. This means that it's not possible to know the full consequences of your choices. However, this is always true, regardless of any management action you do. Not acting can also have the same consequences. I do not take this to be cause for hopelessness. I take it to be cause for humility and open mindedness to "adaptive management" (willingness to change course in the face of new information). You have to make decisions about human medical care in exactly the same context of knowing you need to do something but not knowing everything about the consequences of your choices. I advise studying up, weighing pros and cons, and hedging bets by avoiding doing the same thing everywhere and by avoiding drastic choices of either action or inaction, unless the situation is compelling.

In the absence of such detailed species-specific knowledge covering all life stages thoroughly, the next best outcome results from application of knowledge based on consistent surveys of many entirely separate populations of the butterfly (preferably at least 10-20) for multiple years (preferably at least 5-10 years). The goal here is to get the fullest expression possible of the butterfly species' occurrence across gradients of patch size, vegetative type, and management history. This can provide lots of useful information about the butterfly's apparent preferences for habitat type and management. While inferential, and so not as strong as cause-and-effect, this is the type of information that has resulted in some favorable butterfly outcomes Scott Swengel and I have documented. This approach can also be very useful in prioritizing what needs more detailed scientific study in order to make conservation more effective.

Since it's not possible to know everything we want about a species, and especially since many rare species are poorly known, both consistency and diversity of management are valuable. By consistency I mean sticking with the land use or management that has been going on in a site that's been favorable for maintaining native flora and fauna in the past. Some components of that past are what make the site still of conservation value now. It is very valuable to identify what those components are. Diversity of management *among* sites *of the same vegetative type* leads to a variety of conditions and microclimates. This hedges against one of these choices turning out to be less favorable than expected but you can't anticipate how that future will develop.

But aspire to "consistent diversity." By this I mean avoiding random mixing and matching of management in the same place, whether you're measuring this by site or part of a site. Especially at larger sites, it's possible to do different kinds of management in different parts of the same site but that's not what I'm talking about here. What I'm concerned about is mixing up managements in the same place: mowing a management unit in fall one year, burning it in another, grazing it next. This may be inspired by wanting to reduce the negative effects of any given management type on rare species. But instead this can lead to disfavoring even more species: not letting any subset of species consistently get what it needs but subjecting all of them to things that don't suit them. Random is how nature extirpates populations (the fluke drought, flood, wildfire), and random is how humans inadvertently extirpate populations too. Instead, I suggest zoning management so that each area is consistently managed one way, such as grazing only or mowing only. Sometimes combining managements may be useful: for example, mowing then grazing. That's OK. I suggest viewing that as one of the management regimes to be included in the "zoning" concept.

Both management consistency *within* site and diversity of management *among* different sites *of the same vegetative type* are good practices because specialist butterflies have rather narrow habitat and management tolerances, but each specialist has its own optimal management preference and these differ among specialist butterflies. When I look at a number of butterfly species all specialized to live in the same vegetation (e.g., dry prairie) in a given region, I find that some managements are more favorable for more species than others (e.g., rotational haying over rotational burning in southwestern Missouri prairies), but no one management type is optimal for all these species. When I look beyond butterflies to include moths, birds, and other species, this principle becomes even more evident. Based on both my field observations and my scholarship, I am not able to substantiate the idea that one management type is optimal (or even acceptable) for all specialists needing conservation help in a given vegetative type. However, some specialists need more help and are more sensitive than others. To a considerable extent, successful management for them (e.g., Frosted Elfin, Ottoe Skipper, Poweshiek Skipper) is also adequate, if not optimal, for relatively more tolerant specialists (e.g., Olympia Marble, 'Karner' Melissa Blue, Regal Fritillary).

For the foreseeable future, likely indefinitely, there will not be consensus on how to do conservation management, which I find useful so long as it translates into consistent differences in management among sites. Many find the conflict and controversy frustrating. I'll admit that while it's been a marvelous privilege to see and learn about lots of specialist butterflies in the Midwest, there have been many unfun experiences when sharing what we've learned.

But I also see great opportunity for conservation benefit in all this disagreement if it leads to different site managers using different approaches to site selection and conservation management. This increases the array of possible niches afforded biodiversity. As a practical matter, this also means you don't get an easy guaranteed answer for how things will work out in the approach you select. As a result, it's only through the sum of all the diverse parts all of us contribute that the most biodiversity benefit will be achieved.

I don't want paralysis due to fear of unknowns, but I'm also not giving a license to push ahead with all resources invested in management. If you take responsibility for management of a site, and as a result for particular species in that site, *then you need to monitor and survey and study those species*, even though that requires some investment of time and resources. Idling (no management for one or a few years) can lead to minor changes that can compound (possibly negatively) over years. But dramatic new management can have dramatic effects, including unexpected negative ones. Maintaining long-standing existing or recently prior management, as long as it has no obvious negative impacts (such as tilling) also would have minor effects if continued for a few more years. But stopping old and starting dramatic new managements without baseline surveys can have dramatic effects, including undesirable ones, that you may or may not be able to learn from effectively in the absence of adequate survey data.

I advise at least 50% of resources go toward data collection, with the remainder toward management. I often hear how the managing agency or consortium can't possibly do that. Just not enough resources, not enough time, it's too important to implement conservation management before it's even too late. Let me ask you: Would you find it acceptable for a doctor to start treating your symptoms without any tests? No medical history (yours and your family)? No knowledge of your allergies, other medical conditions? After starting treatment, would it be OK with you if this lack of monitoring continued, with all resources toward treatment and none toward tests and monitoring your condition? Even in as dire a circumstance as a person requiring resuscitation, the method is not just doing something (e.g., chest compressions) but also periodically monitoring (e.g., checking for a pulse). Likewise, the more you study available knowledge on the species in your site and obtain survey data, the more effective your management activities will be. Expert volunteers may be available to provide surveying and monitoring data. The largest monitoring programs I know of rely heavily on volunteer contributions. The more volunteers see their contributions valued and used, the more likely they are to continue participating.

Why not just do the ecosystem approach to conservation, to avoid the problems of inadequate species-specific knowledge or conflicts among species? If we define the ecosystem approach as working simultaneously on the conservation needs of multiple particular species occurring in the same site, then yes! Let's do that. If we define the ecosystem approach as restoring processes (regardless of type or types—fires, floods, grazing, etc.) and letting whatever happens happen, I advise against that. I don't see how we can know more about the function of ecosystems, especially pristine intact ecosystems such as tallgrass prairie that have not existed for several centuries, than about species we can still observe and study today. Furthermore, how do we know that those processes have the same effect now in our current landscape context, which is much different from back then? Without sufficient knowledge, we can't know whether or how much we are doing the ecosystem approach "right" (effectively, favorably), any more or less than we can know whether our species-specific approach is "right."

I advise aiming for something in the middle that I think is more achievable and effective: "co-occurring" species assemblages. Even in a program as focused on a single species as the Large Blue re-introduction in England, associated species that prefer the same habitat and management benefitted. Scott and I certainly see that in our surveys: "good" sites are good for more than one butterfly species of conservation interest, as well as birds and plants. These outcomes are also non-random. When I look at good sites, I can identify factors that associate with larger populations of those rare species, which I describe below. I've also been to lots of large nature reserves that are being managed for the "ecosystem," but whatever that is, it does not include very many species or individuals of specialist butterflies characteristic of that ecosystem, and sometimes none of these species. So, ironically, it appears to me that aiming for something less than an entire ecosystem, aiming instead for something more identifiable and concrete (a specific set of species of conservation concern), actually results in more of an ecosystem of rare biodiversity, *so long as* that approach aimed at co-occurring species is grounded in monitoring the target species and basing management on specific knowledge of those species.

Most ecosystem-process approaches I've seen actually focus on prevalent plant species (vegetative classifications) but I advise an opposite approach: working up from the rarest species reliably occurring in a site. Focusing on native vegetative cover types actually means focusing on relatively common (if native) plants. But widespread species are not good "stand-ins" for rare species, plant or animal. The more common species, while native, occur in a wider range of conditions and sites than the rare species. So I advise focusing most on the rarest species native to that site, and working "up" from there, as much as resources allow. For example, if Frosted Elfin occurs in your site, focus on it, as the needs of Persius Duskywing and Karners appear to nest largely within (as well as beyond) that. At Buena Vista Grassland (the subject of another article published online by SWBA), the Greater Prairie-Chicken is the focus (a very rare bird, indeed, in Wisconsin) and this results in an astonishing diversity and abundance of

other grassland birds. If your prairie has both Regal Fritillary and Ottoe Skipper, try to hang on to the latter and likely the Regal, a specialist for sure but not as fussy about vegetation or management, will fare acceptably too.

That's why I advise against doing things just because that's "how it's done;" instead have a reason specific to a species. I see a lot of management being done because it's "natural." It's being done because it's thought that it is in some way replicating what generally happened in the past. But do you know whether that really happened all that often in the microhabitats for the species you know occur in your particular site? Don't just do things because you can. Have a reason specific to the species there now. Then you can tell whether you are achieving the result you want or not. When you focus instead on general processes, you may not be considering whether the resulting microhabitats are suitable for the subset of species living in your site. When you target management to specific species and monitor them, there's more chance of figuring out what helps and what hurts them—"adaptive" management that makes it possible to improve outcomes.

I advise selecting management not just based on surveys of what lives in the site, and not just based on which management produces what effect, but also on the land use history of the site. It has seemed to me that at the time of conservation, most conservationists focus on what they see as *wrong* in the site and on *how to fix that*. They are looking ahead toward the future, to what they want the site to become. I recommend instead a focus on what's *right* in that site now—why it deserves conservation attention and *how to retain that*. I look first to the past. I want to understand how the site got to be the way it is now, worthy of conservation, so that I can then work to retain that in the future. By logic, the history of the site has been more favorable than at other typical sites in the landscape that offer less for conservation value. As a result, it is extremely useful to know the land use history of the site, just as it is extremely useful for your medical practitioners to know the medical history of yourself and your family. It is logical to expect that the species in your site will be skewed toward those preferring the prevailing management in the site's history. However, by no means do I assume that to be true for all species in the site and it is definitely possible that some species of conservation concern have been barely managing to continue to exist there. After all, the management of the site in the past has probably been constrained by the desire to be successful agriculturally. Conservation is not constrained by that limitation, and so has the option to improve the past management practices in the site to be more beneficial for more biodiversity. However, that is most likely to happen by working with the management history of the site and maintaining continuity with that instead of fighting it or drastically changing to a different management type.

BURNING

Here are recommendations on fire management in the context of insect conservation from eminent entomologists in southeastern Australia, another region where many believe in the ecological benefit of frequent fire in natural habitats. Dr. Tim New is the lead author of this paper in the *Journal of Insect Conservation* (published online and in paper as vol.14, issue 5, pages 567-574). First the authors note the relative paucity of data on long-term population trends, habitat requirements, and management tolerances of rare and specialized fauna in their region. As a result they advise a scientific approach with controls to hedge against both what is and isn't known. This is to try to optimize the future of biodiversity even with these gaps in knowledge. Those observations are highly appropriate to the Midwest, as are their recommendations, which are as follows: (1) Sites that are small or isolated or have listed invertebrates should never be burned without carefully assessing specialist zoologist advice. (2) Micro-mosaic burns no more than a few acres each and staggered over years should be the norm instead of larger burns. (3) At least 20% of a site should be permanently protected from deliberate burns (that is, never burned). (4) Small sites (less than about 10-15 acres) should only be burned under exceptional circumstances, and then only with surveying and monitoring to investigate risks.

I do not recommend burning for butterfly conservation in the Midwest, even if done in rotation. Based on numerous studies and our long-term datasets at many sites, I see too much risk to butterfly population viability due to the direct fire-caused mortality to the butterflies in the site, even when only part of a site gets burned per year. Over the long run, this often leads to reduced numbers of butterfly species and individuals in the site, not just specialist butterflies but butterflies in general. There is not a fixed recovery time for a butterfly species. Recovery, if it occurs at all, depends not just on ensuring that enough individuals survive outside the burn within nearby recolonization distance but also on annual fluctuations after the fire happens. That affects how long it takes for the butterfly to rebuild its numbers, and some years and strings of years are not conducive to a species' increase in numbers due to unfavorable weather. On burn day, it is not possible to know what future weather will be like and whether the next several years will favor or disfavor particular species in becoming re-established in the burned area.

I also see that useful floristic effects can be adequately obtained by means less lethal than burning and some vegetative effects of fire, even ones promoted as beneficial, do not appear applicable to butterfly conservation. Firstly, the complete or nearly complete removal of accumulated dead plant matter ("litter") removes a valuable resource for animals. For butterflies, some plant litter can be useful in all life stages as shelter from predators and a buffer against extreme microclimates (both desiccation and

extreme cold or heat). This buffer applies both to the butterflies themselves and to the plant resources they consume. That buffer applies within or below the litter. Conversely, the surface of brown litter can be warmer than green vegetation in spring, allowing caterpillars and adults to achieve warmer than ambient air temperature and therefore greater activity in cooler weather. Eggs may be laid on litter rather than living plant tissue. Alternatively, eggs may be laid on live plant matter, but before they hatch next year, that surface becomes litter. Chrysalises can be attached to litter or what becomes litter. Heavy plant litter can reduce growth and flowering of some plants. This can be unfavorable if a butterfly's required resources are inhibited. But if competitors of these required resources are what's suppressed instead (including brush or weeds inappropriate to the habitat), then this can be useful. Interestingly enough, even when required plants are inhibited by litter, this may be useful by preventing too vigorous and coarse plant growth. Caterpillars do not necessarily prefer to consume plants growing at their maximum potential but instead may more be able to consume weaker, softer plant growth. Thus, the benefit of litter needs to be balanced with the benefit of maintaining native floristic diversity and fresh new growth. Ideally, both of these benefits are provided consistently. Secondly, the shift to taller grass that often results later in the same growing season after a fire, and the shift toward relatively more grass than wildflowers that often happens after years of fire management, are vegetative structures that tend to be less favorable for butterflies. Thus, even if enough individuals survive so that the population "should" recover, after several completions of the rotation, the vegetation may no longer be suitable to support as many individuals as it used to.

Rotational fire regimes usually meet my definition of intensive (high risk) fire. I am basing this on my observations of butterfly outcomes throughout the Midwest over more than two decades, both in highly fragmented, small, and isolated tallgrass prairie sites and in larger less fragmented landscapes of both prairies and barrens. My definition of intensive fire is about 20% (or more) burned in one year, with most of the site in fire management over the course of about 5-10 years (or less). My definition of unintensive fire is less than about 10% burned in any given year, with substantial areas (at least 20 acres and 25% of the site) never fire-managed over the course of decades. These are approximate numbers, intended to function as context and order of magnitude. I am NOT endorsing either of these kinds of fire. My purpose is to define terms as I see suggested by the butterfly data. My definition of "unintensive" fire and my threshold for "intensive" fire are much lower fire than the widespread view in midwestern conservation today.

If fire management occurs in a site, the most beneficial step is to maintain a never-burned area (permanent non-fire refugium, or "perm") in core habitat for specialist butterflies, with unintensive consistent alternative management as needed to control brush and weeds and maintain adequate caterpillar resources. This never-burned area is called a "permanent non-fire refugium," with my slang shorthand of "perm" for that. The full-length term I'm using here is cumbersome and the obvious shorthand for it (refugium) has been used for various other meanings (e.g., fire-managed but not burned in the last year) that I do not intend here. The goal is to prevent both deliberate (management) and unplanned fires in the perm.

Core habitat requires a butterfly species-specific definition. It is not based on vegetative cover maps. It is based on where the most caterpillars and adults occur. If you only have adult information and do not have caterpillar information, then you need even more buffer to ensure that you include enough essential resources in your perm. When the butterfly is highly concentrated in a site, then most or all of that area can be designated as the perm. But the butterfly remains highly vulnerable due to that concentration, and the prevention of accidental fire becomes paramount. When the butterfly is more widely distributed in a site, then I'm estimating the advisability of at least about 25-50% (or more) of the primary adult activity areas and 25-50% of the caterpillar resources in the perm, which may not coincide. Adult specialist butterfly activity areas are often a good (if approximate) guide to primary breeding (caterpillar) areas. Likewise, caterpillar food plants do not equal butterflies—it's often the case that primary caterpillar production areas are only a subset of all the caterpillar food plant patches. Thus, in the absence of more specific knowledge on the caterpillar production areas and since these locations can vary among years, you need to protect more than is identifiably essential to the butterfly because you are not able to pin down more precisely what actually is essential to the population. Likewise, I advise using multiple years of butterfly location data to identify core areas, since the concentration areas can vary among years (for example, between drought and flood years) and you cannot anticipate which area will be more valuable to the population in a future season. If the butterfly population is very fragile, even sometimes subdetectable, then it's useful to rely on long-term data to identify the areas that have reliably been important for the population in the past. It's also important to identify enough minimum acreage, again as a buffer against what you don't know. I would throw out a number of at least 5-10 acres minimum in a perm (although that is a very small and vulnerable size), but preferably at least 20-25 acres. Management alternatives to fire that I encourage to use as needed in the perm are discussed later in this section.

If a permanent never-fire-managed area does not exist, two options exist. First, a formerly fire-managed patch can be made into a permanent non-fire refugium, but this requires at least 6-8 years since last fire to start serving as such, and may not be as effective as a never-fire-managed area. A second option is the temporary refugium: identifying where the immatures of the target species primarily occur now (based on field surveys), and ensuring that those

areas do not burn in the specific fire being planned to occur in the next few months.

Relative and absolute scaling of fire can also ameliorate negative effects of burning. I previously threw out an approximation of 10% or less burned per year as a relative definition of "unintensive fire management." But I need to add these general principles for absolute definition of unintensive fire. As the Australian entomologists point out, some sites are so small (on the order of 10-15 acres or less) that any fire becomes risky and so burning should be avoided and prevented altogether. But in larger sites, size of contiguous burned area also matters. That's what the Australians mean by "micro-mosaics" of fires, in contrast to large contiguous burns. So maybe that means a 1-acre fire plot if it's a 20-acre site, a 10-acre burn plot in a 200- acre site, and plots not bigger than 100 contiguous acres if the site is 2000 or more acres. These are approximations meant to provide some scale for the cap on contiguous area burned. The goal is to reduce the likelihood of inviably small unburned areas in small sites and reduce the risk of burned areas being too large in large sites that recolonization throughout the burned area cannot be reliably achieved within the timeframe of the fire rotation. The maximum burned per year in all years needs to be 10% or less, ballpark. It's not just the average burned across many years but also the maximum burned per year that matters.

In addition to never burning core areas for specific butterfly species, it's also wise to divide up management units by basic vegetative cover types, for the purpose of permanently protecting a portion of each from fire, and for the purpose of ensuring only a minority of the remainder gets burned in any given year. This is for the purpose of using the principles learned from the species we do know about in the hope of extending benefits also to other species we know very little about. I categorize vegetation not only by the standard vegetative classifications (e.g., oak savanna, pine barren, wet prairie, dry prairie, fen, etc.), but also by gradients of degradation and human impact/use. For example, the butterflies in semi-degraded formerly grazed prairie are different from the butterflies in lightly hayed high-quality wet prairie that was formerly hayed. Degraded old field that has a periodic grazing event (or "disturbance" in the ecological lingo) can be wonderful for maintaining the weedy caterpillar plants that some butterflies like Gray Copper love, but that kind of soil-exposing disturbance runs the risk of establishing non-native weeds in never-tilled high-quality prairie flora. Once the various vegetation types are identified, with as much specificity as is practical for the site size and history, then the goal is to divide them up as evenly as possible in as many different management units. This is to make it possible to establish permanent non-fire refugia, and to apply the relative and absolute guidelines for what gets burned, apportioned by each individual vegetative classification. It's up to managers how much effort is put into drawing boundaries and breaking down the property into smaller units. The more you're hedging against unknowns, rather than acting based on positive data (larval and adult locations) and positive knowledge (the resources and conditions they require; management associated with positive outcomes), the less certain the benefit to biodiversity. I can't guarantee an identifiably better outcome for something in the absence of that data and knowledge. But the more these practices are done, the more benefit I would expect. My point is that these are all practices that appear highly worth the effort in terms of long-term benefit to rare biodiversity.

Other suggestions (wet burns, winter burns, summer burns) appear relatively less effective at ameliorating the negative impacts of fire on butterflies. The suggestion to burn when it's wet or in winter may arise from an attempt to reduce fire-caused mortality. But these appear uneven and unpredictable in what, and how much, they do or don't kill. It appears to me that the more distinctly measurable benefit comes from entirely unburned patches, not from incompletely burned fuel. Furthermore, the fire needs to be effective at what it is intended to do, and a manager may not be satisfied with wet incompletely combusted fuel. As a result, such fires may result in even more fire to fix such fires. That appears to be a counterproductive outcome for butterflies. Alternatively, another suggestion is to burn in summer, when it is thought that butterflies (and other insects) would be more active and able to evade the flames. This does not ameliorate the shock phase that follows a fire, which is the source of some fire mortality. Furthermore, there is no time when most butterfly species are in the adult life stage. Most are in immature life stages at any given time, even in summer, and so are not capable of rapid evacuation, or even any movement at all, out of a burning unit.

Another suggestion I do not recommend for butterfly conservation is doing the same amount of burning as before but with additional other managements to improve the vegetative outcome. For example, in floristic studies, overall prairie floristic diversity can be higher when burned sites are also hayed or grazed. This can reduce the shift to more and taller grass that I have previously described. However, in these plant studies, combining burning with another management (haying or grazing) usually did not enhance plant diversity over just haying or grazing. I also would caution that this approach adds the possibility of even more management risk for insects—they have to be tolerant of both fire and the alternative management, as well as the increased frequency of management activity. The lessons I draw from all this is that it is more effective to have a deliberate notion of what exactly you are trying to achieve with a fire and to protect from the fire rather than doing things that appear theoretically to reduce negative impacts but do not specifically identify what is being shielded from fire. In this specific case, I would advise reducing the burning and focusing instead on the alternative managements that produce the more favorable vegetative

effect.

It's possible to adhere to a fire paradigm and still be successful in rare species recovery without using fire. I do not believe the evidence points to the existence of frequent fire (e.g. 5-10 year fire return intervals) or the pervasiveness of fire (most or all areas experiencing regular fire) in the Midwest prehistorically (before Columbus). But many believe in this, which I call a fire paradigm. Nonetheless it is possible to reconcile an acceptance of frequent fire back then and still use other approaches to habitat management today. For example, the Kirtland's Warbler in Michigan has rebounded due to cowbird control and sequential forestry that maintains a steady supply of young pine growth for their nesting habitat. The fires that most generated the appropriate habitat result were unplanned, out-of-control disasters, not controlled burns, so that safer management with rotational timber cutting replaced that. It is possible to believe that large prairie fires used to occur but with even larger areas not burned then or recently. This approach recognizes that it's impossible now to have both a large fire and a large unburned area in a small preserve.

It behooves reserve managers to protect rare biodiversity from unplanned wildfire. The challenge is making sure the preventive measures aren't dangerous or risky too. Burning the fuel that could become an unplanned conflagration is a wildland fire preventive technique used in other regions with extensive fire-prone vegetation. However, the benefit is short-lived. As soon as that vegetation grows back, if it's not a drought, the fuel is back in abundance as well. Thus, I view deliberate burning as a very valuable fire-fighting technique, when the wildfire exists and needs to be contained. However, as a long-term management method for preventing uncontrolled wildfire, it is relatively expensive and risky (some of these fires also get out of control), as well as hazardous to biodiversity sensitive to fire. It may just result in more total fire happening. Plowed firebreaks are effective as well, and directly affect a smaller land area than gets burned, but is an agent for increase and spread of non-native adventive plants. Likewise, controlled burning also allows the spread of non-native plants by baring the soil surface and establishing a harsh microclimate, both of which favor recruitment of weedy plants. As a result, two other methods to maintaining firebreaks bear consideration: mowing/haying and grazing (discussed below).

What if the site has been being burned for several decades. Do you advise continuing that to maintain the consistency you advocate? It may be justified to reverse the burning of part or all of such a site if there are fire-sensitive rare species that have managed to survive. They may warrant what my British colleagues call "more sympathetic management" to increase the odds of their continued viability in the site. You may be wondering if I don't care about fire-favored rare species. Actually, I care about all rare species, but it's been very difficult for me to find studies with breadth of time and number of sites that demonstrate fire-dependence by rare species (i.e., species that require fire and cannot be managed some other way also). If such fire-dependent species exist, then they need to be cared for in a way that accommodates both them and the fire-averse rare species I'm describing here. However, the species that tend to benefit from fire tend to be more common and widespread species, plant and animal. I believe that is because fire results in an extreme variation in habitat condition throughout the fire cycle, from combustion through bare shock phase through dense regrowth. Furthermore, natural fire (not ignited by people) is typically highly variable in frequency and extent. Species that benefit from fire usually need to be able to succeed in the absence of fire too, in order to persist long-term. By contrast, rare species tend to be more narrow in suitable habitat conditions, which can only occur in part of the fire cycle, if at all. However, while I do not recommend fire at all, there can be this justification for continuing to burn in these longest fire-managed sites. If concentrating fire in these longest fire-managed sites means a result that other sites will get less or no fire, then that's the choice I'd pick.

In nature, an example where fire produces relatively more favorable butterfly results is when a single wildfire creates new habitat that butterflies in unburned habitat (long unburned) within colonization distance can occupy. This wildfire is stand replacing (converts forest canopy to opener habitat). But this is only one side of the wildfire story. Other examples of wildfire result in long-term extirpation, or do not generate open habitat (a thicket regrows quickly instead). That's why I recommend trying to obtain the positive effects wildfire can produce by aiming for the kind of wildfire that has desirable butterfly conservation outcomes. This means using fire to create habitat where the butterfly currently isn't occurring but can reach to colonize if suitable, rather than using fire to maintain habitat currently occupied by the butterfly. Alternatively, take the obverse lesson from wildfire by avoiding the drastic approach that stand replacement (by any means, such as wildfire and clear-cutting) is about. I have an underlying concern about drastic (boom-bust) cyclical approaches to habitat management, compared to a more consistent approach. Specialist butterfly populations appear more likely to persist more often in stable consistent habitat (as can be obtained with management described below) than in boom-bust cyclical habitats, although some specialist populations can be found in some examples of wildfire burns, clearcuts, and so on.

MOWING/HAYING

Throughout this series on management, when I discuss conservation applications of mowing (mechanical cutting that leaves the cut vegetation to lie in place) and haying (mowing with removal of the cut vegetation), I mean a single cut per year in an area of native herbaceous vegetation, not the entire patch and not more often

than that. In areas degraded by weeds or brush, it may be appropriate to do more frequent cutting in those localized problem areas. For example, several cuts per summer may be useful to prevent seed set of a non-native weed. The cuts may be set high enough to reduce negative effects on non-target plants as well as animals.

Mowing and haying are more favorable for more midwestern butterfly species than burning. A single treatment of mechanical cutting causes less direct mortality because the treatment itself is less lethal and results in a shorter, less pronounced shock phase afterward due to more resources remaining than after a fire. Furthermore the vegetative results of mowing/haying can be highly favorable for butterflies of open habitats. Mowed/hayed vegetation tends to be very open (herbaceous, as opposed to brushy), with a shift to a shorter opener herbaceous vegetative structure that is relatively flower rich. I'm not going to distinguish between the two managements here. While I have a surveyed a lot in these managements and read a lot about then, I do not have direct comparisons within a vegetation type and region between these two managements.

However, mowing and/or haying, or certain kinds of them, are not favorable for all specialist butterflies in the same vegetation type. Even though mowing/haying causes a briefer "shock phase" than fire, that shock phase may be precisely timed for maximum negative impact for a given species by removing a vegetative resource when it is most needed. This negative impact is most pronounced for caterpillars, which do not usually have adequate dispersal ability to exit the cut area and may starve, while adults are typically more able to survive by emigrating out of the cut area.

Mowing/haying should be done in rotation, not treating the entire site at once in a year, in fact not treating all of a particular vegetation *type* at once in a year. Even the specialist butterfly species that abound the most in mowed/hayed sites usually are more abundant in the part of the site that was last cut more than a year ago. In very warm climates with rapidly growing vegetation, as in Missouri prairies, a two-year rotation had remarkably abundant Regal Fritillaries and Arogos Skippers, with more of each in the part cut longer ago in our surveys. However, farther north, it appears advisable to think in terms of 3-5 year rotations (20-33% maximum cut per year). This could in fact also be beneficial farther south but I don't have as much data on that. As with burning, so also with mowing/haying, it is beneficial to map the vegetation types (as described in the section on burning above) to make those percents of cut area apply not only to the site overall but also to each individual vegetation type.

One method to ameliorate the negative impacts of mowing/haying is to vary the timing of the cut, but I advise to do that in a consistently diverse manner rather than a random one. There is concern that cutting at the same time each time consistently disfavors the same species, even as it consistently favors others. The thought is to retain more biodiversity by varying the timing of the cut, so that the same species don't keep losing each time. However, my concern is to focus instead on ensuring that the species that thrive in the site keep consistently getting the conditions they prefer, which mowing at the same time each time does. Thus, I encourage zoning the timing of the cut so that each unit is consistently cut at about the same seasonal timing, but that seasonal timing of cut is made to vary *among* units. This allows the species to sort themselves out by their preference and consistently obtain their preference so that the site overall has the chance to support more species.

Another method of reducing negative effects of mowing/cutting is to reduce the homogeneity of the mowed unit by strip mowing. Mowing/haying is relatively homogeneous because it is non-selective—all plants get cut. As a result, they are all the same height, both right after cutting (when they are all short) and later on as they regrow. By contrast, with light to moderate grazing, the cutting of the plants is selective, resulting in a more heterogeneous vegetative structure. However, such grazing also is highly selective in a negative way in that the most palatable flora gets continuously impacted the most. By contrast, mowing is less selective, in that all plants get treated the same way. Differential impacts primarily result from where in the growing cycle the plant happens to be at when the cutting occurs, with plants actively growing toward flowering harder hit than those that are not actively growing yet or already done with active growth. A way to obtain the more heterogeneous structure of light/moderate grazing while also avoiding the negative continuous selectivity of that management is to mow a strip then skip a strip (or two) and keep alternating that way through the unit. The advantage of strip mowing is that animals requiring one of these vegetative structures can overlap their home ranges on top of those for species requiring the other structure, instead of being segregated from each other in the case of larger patches of more homogeneous vegetative structure. Another advantage is that animals which benefit from both structure in the habitat, or the edge between them, obtain more habitat. While I am discussing this approach based on both what I've seen and heard about it, I do not have much rigorous analysis on it. Thus, this approach warrants more scientific study.

Mowing in summer increases negative impacts on insects but also appears to favor flower diversity by reducing dominance of dominant grasses. Mowing in fall reduces negative impacts on insects but may favor dominance of grasses. Summer cutting must be done in rotation (e.g., over 3-5 years) because of the immediate negative effects for insects. However, the consistently short (1-3 feet tall) vegetative structure and floristic diversity that result from summer mowing/haying result in excellent butterfly habitat. Fall haying can result in more grass-dominated vegetation, although some wildflowers are still present. The vegetative structure is still relatively short, which appears more favorable than tall (>3-4 feet tall) thick grass. This

management can be outstanding for Dakota Skipper. This should still be done in rotation but it may not be necessary for this cycle to be longer than 2-3 years.

Should a site managed with mowing/haying have a permanent refugium from mowing/haying, maintained as needed with another management (e.g., grazing or localized brush-cutting)? On the principle of hedging bets, this has merit, especially if the refugium encompasses core habitat occupied by a species vulnerable at the time of the mowing/haying treatment for which you have positive evidence of what management it prefers instead. But I don't have evidence I can point to, in my field surveys or published studies, that such a refugium provides measurable benefit if the site is also rotationally managed as I've recommended above, especially if there are consistently different treatment timings.

Lots of mowing and haying occur in the Midwest but it can still be difficult to get adequate data on these managements in conservation applications for many species and regions. In many regions, most haying is not done in a conservation application, and so is more frequent or larger in extent than recommended for conservation. More mowing occurs in conservation applications, but much of this is in areas also being managed with fire. In that case, it is difficult to determine the effects of only doing mowing without any burning. As a result, I hope to see more conservation applications of mowing/haying (alone) and to read more about them, so that I can learn a lot more about them in the coming years.

GRAZING

Although I have survey experience in a variety of grazed sites, I have less experience than I do for burning and mowing/haying. Grazing presents the most variables: continuous or rotational; broadcast or localized; season, duration, stocking rates, species/breed of stock, and so on. Technology such as temporary electric fencing allows great flexibility in paddock location and size. Light to moderate grazing in the growing season each year or most years has the benefit of reducing immediate negative impacts on both plants and animals that comes from heavier grazing, while also reducing overshadowing grass, brush, and palatable tall weeds such as sweet clover. On the other hand, such sites are often "scruffy" (moderately degraded), especially with unpalatable weeds, which leads to the concern of the site's trajectory into the future, with possibly more deterioration. A brief period of heavier grazing, at least focused on the brushier weedier places, may improve the floristic condition afterward. But this has to be counterbalanced with the greater negative impact of intense grazing on the butterflies, as well as a lot of the native flora too. I advise against protracted heavy grazing of primarily native herbaceous flora. This can be beneficial for brush control in old fields (already degraded herbaceous flora, especially following a mow or burn of that brush to stimulate palatable fresh growth.

A logical recommendation that flows out of that is the use of mosaics, both rotating over years (with ungrazed years in between) and varying grazing intensity among plots (including some areas not grazed at all). Units need to be designated and the more the core area of a butterfly is distributed among more units, rather than concentrated into a single unit, the better. The more you use multiple years of data to identify core areas the better. Vegetation types can be a surrogate for designating core butterfly habitat, with the caution that vegetation types are not perfect surrogates but in the absence of butterfly data, they are better than nothing. For example, all high-quality dry prairie should not be in a single unit. This can be inconvenient but go to the trouble. Other habitat factors can also be evenly distributed across different units. For example, the east slope and the west slope of a site may both be high quality dry prairie, but have obvious differences in particular plant species present. Treat each as a separate vegetative type as a result. An additional valuable part of the mosaic can be a permanent non-grazing refugium, with localized treatments to control brush and weeds if and as needed. Placement of watering areas can also lead to gradients of grazing intensity across a site, which increases the heterogeneity of the grazing mosaic.

But I advise against random grazing mosaics. I recommend having a starting point for why you think you need to do something that involves a particular species, not abstract ecology. Otherwise, your mosaic may be offering habitat for species that don't live there, and as a consequence, removing habitat from those that are there.

Much additional research is needed on grazing before I can provide more recommendations. A lot of grazing occurs in the Midwest but relatively little of it occurs in conservation applications, and relatively little of that occurs in native prairie flora. That means there's lots of benefit to proceeding ahead cautiously while taking lots of data on the kinds of grazing done and the kinds of plant and butterfly responses that occur. That way, I hope to learn a lot more about grazing and butterflies in coming years, and to be able to provide more detail and conclusiveness in my recommendations.

IDLING (DOING NOTHING) AND LOCALIZED (SPOT) TREATMENTS

Doing nothing may be inadvertent, due to an oversight or lack of resources, but it can be a deliberate choice. For my purposes here, I define "idling" as at least 8-10 years since last management, since active managements may be done in rotations over a time frame of that long. If idling is a deliberate management choice, then I think of that as the plan for some years into the future, or until an obvious deleterious change in the habitat or butterfly population is evident. In that case, a broadcast management (burning, grazing, mowing/haying) may occur. But another

option is a spot treatment (bush-hogging, mowing, spot-herbiciding) that may occur in the problem area, leaving large open herbaceous areas still idled.

Vegetatively, idling offers resources useful for animals. Relative consistency in vegetation occurs year to year, even though over the long run the vegetation may still register changes. Accumulated litter can be a useful resource, as discussed above in the section on burning. Brush invasion is a concern, but some idled plots are relatively unbrushy, and if so, and if the sod and litter are dense, then brush may be slow to get established and expand there.

I think of idling not usually as an indefinite strategy in midwestern grasslands and savannas but as an appropriate interim strategy. During a management idling period, surveys and monitoring can occur while management is being studied, available resources assessed, and the site history learned.

However, long-term idling in conjunction with localized treatments as needed can be a viable long-term management plan. I advise this in places with what appears to be relatively stable vegetation that does not appear to have brush or weed problems. I caution that what looks stable to us humans may not be so in the subtle ways that may matter to a particular butterfly requiring specific resources and conditions. However, as I've already outlined elsewhere, active management is also fraught with uncertain effects and outcomes. So even with that subtle risk, doing little or nothing can be a relatively effective approach. The most obvious downside would be for those butterflies, such as Gray Copper, that use weedy plants (docks), which may fare better in actively managed sites where bare or lightly covered spots allow plant regeneration. On the other hand, many other butterflies use long-lived herbaceous perennial plants as caterpillar food, and these plants are more likely to maintain long-term consistency if the vegetation is already in a stable high-quality condition and no soil-exposing events occur to alter that condition. A benefit of this approach is that there is less risk of adverse reaction to a management activity because the area that management occurs in is small. In this way you can experiment with less risk. Furthermore, you can target more drastic management to the specific areas that need it (e.g. brushy spots) while avoiding negative impacts to specialist butterflies of open habitats, because they are mostly in the more herbaceous unbrushy parts.

TIMBER HARVEST

It's outside my expertise to make specific recommendations on how to cut trees in either spot or broadcast treatments. My comments here are directed at consequences for the site following tree cutting. My observations suggest the value of not disturbing the soil surface. This improves the natural regrowth of native flora already in the site and does not encourage non-native plants. It appears preferable to remove slash (cut tree material) from areas of herbaceous flora as much as possible. This can be either removal entirely from the site or hauled to shaded areas in the site under trees that are planned to remain standing. If removal is not an option, pile slash (to reduce area it's covering) but do not burn the piles, as the latter can kill the herbaceous flora underneath and sterilize the soil. This can lead to weed proliferation in those spots, which in turn poses the risk of spread outward from there. Cutting a large contiguous area would be more likely to cater to grassland species while cutting smaller strips or patches would more likely cater to savanna species (discussed further below in the section on heterogeneity). Log landings (loading zones) should be placed in lower-value areas as these are highly disturbing to the ground layer.

While it may be more efficient to cut all the trees at once, more gradual cutting reduces the risk of weed and brush proliferation. When a large area is cleared, this may tip the balance more in favor of weeds which are better able to establish quickly in large areas. More gradual clearing may tip the balance more in favor of more regeneration by native herbaceous flora, and if not, at least it makes human intervention to reduce weed proliferation more manageable.

If a large wooded area is clear-cut, species expected to benefit would primarily be colonizing in from outside, rather than surviving within the cut area. In that case, where it's about colonization rather than retention of the butterfly, studies vary on whether burning the cut area is useful or not. This is likely to depend on whether the burning is useful for obtaining the desired vegetative result. It's also possible that useful effects from fire aren't so much due to the burning but due to a second treatment (in addition to the initial cut) being done. In that case, repeated treatment of another kind (such as more cutting or more removal of slash) may also obtain the desired result.

HETEROGENEITY

While not a specific management method, habitat heterogeneity is discussed frequently in connection with insect conservation management. Habitat heterogeneity means a diversity of habitat conditions—wet and dry, shaded and sunny, and so on.

The benefit of heterogeneity is that more niches for more species can occur in the site, but this may be at the expense of specialist species requiring a large area of a particular habitat type. Increased habitat heterogeneity usually associates with a higher number of species living in a site. However, a downside of heterogeneity is that some species of conservation concern require a relatively large area of their preferred habitat to sustain an isolated population viably. Efforts to increase habitat heterogeneity can actually reduce the total amount of habitat for these species. Thus, habitat heterogeneity is not a guaranteed benefit for all species.

Furthermore, restoration efforts to reduce habitat heterogeneity may in fact have conservation benefit, even if they reduce species richness in a site. For exam-

ple, if a site has species of conservation concern that require open habitat, but the site has been increasing in canopy, then canopy reduction can adversely affect species associated with the canopy (often generalist species) but benefit the open-habitat species.

As a result, I advise that you do not want to do heterogeneity for the sake of it, but for a specific purpose. Focus on the consistency of resources and conditions required by the species you are targeting, and work to maintain that. Many species benefit from some variety in these resources and conditions, and out of that, habitat heterogeneity results, but in the manner of targeted consistent diversity as I described earlier in Part 4. Also, as part of your research on your site's history, you may learn about the kinds of mosaics and heterogeneity that have traditionally existed in your site—for example, one area traditionally hayed and another traditionally grazed. Following that site history encourages habitat heterogeneity likely to be beneficial to the biodiversity still in your site.

I call a kind of habitat heterogeneity "vegetative layering." I first noticed this in Bauer-Brockway Barrens (included in another article published online by SWBA). It struck me as amazing that I could stand in one spot and (in appropriate seasonal timing) see butterflies typically thought of as restricted to grassland (Cobweb Skipper, Gorgone Checkerspot), savanna (Frosted Elfin, Edwards' Hairstreak), and forest (Northern Pearly-eye, Little Wood-satyr), as well as abundant numbers of species that grade between several of these habitat types ('Karner' Melissa Blue, Aphrodite Fritillary). The most diverse butterfly sites I know of, ones that include the best specialist faunas but also long lists of butterflies in general, are ones that have this "layering" of different vegetation types right on top of each other. I see this also in bogs (the subject of another article published online by SWBA). A Douglas County muskeg is a bog to Freija Fritillary, yet it's a damp heath to Pink-edged Sulphur, a peaty sedge meadow to Eyed Brown, a wet meadow to Silver-bordered Fritillary, a soggy grassland to Common Ringlet, and a forest however scraggly to Atlantis Fritillary. It's not possible to draw boundaries for these different vegetation types because they're superimposed on each other. Even grasslands can have this layering—for example, we have found nests of Henslow's Sparrow (found in thick dense litter and turf) and Grasshopper Sparrow (found in opener barer turf) near each other within the same management unit.

I want to advise against inadvertent reduction in habitat heterogeneity by reducing this "vegetative layering." For example, brush and tree cutting can be aimed at maintaining a mix of open vegetation and forest. If only measured on the scale of the site, this goal can be achieved by a variety of means ranging from lots of small areas cut to one large cut. For example, the goal may be 50% woods, 50% grassland. But how this ratio of 50/50 is achieved may get very different results when measured at the scale of the butterfly. If, for example, the individual cuts are so large that only open habitat butterflies use it, this makes the openings unattractive even to savanna species like Frosted Elfin, much less species associated with more wooded cover. On the other hand, if the mix of open and forested is approached on the microsite scale, so that openings are 10-20 feet in diameter and trees occur in groves and patches, then this fosters the layering I described above, with grassland, savanna, and forest species occurring in the same small areas.

CONCLUDING THOUGHTS

How can I only be discussing butterflies here? It's certainly true that any management you do for butterflies in a site will affect everything else that lives there or could use the site in the future (e.g., migratory species). I don't expect anyone to manage only for butterflies. However, I think it's important to consider the full range of management possibilities as they affect particular butterfly species in particular contexts. It's not helpful for me to filter what I say to be only what I perceive to be "acceptable" for other species or other goals. I don't expect anyone else to do this filtering either. If a book is about bird management, I don't expect to find anything in there about butterflies and I don't want them omitting something useful for birds that they think may not suitable for something else. I've never seen an exotic plant control manual that only discussed management treatments certified safe for rare butterflies. I think that the best decisions for management of multiple species come only from fullest possible disclosure on each species.

All my recommendations are based on my current understanding of my observations and readings. I expect my understanding to change in the future. This could be because of future observations and new studies. But it could also result from my running across an old study I'd not read before, or a new way of thinking may develop for understanding observations and studies I'm already describing here.

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