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# Coming to Public Lands Near You

*by V.J. Tepedino*

Are honey bees (*Apis mellifera*) benign or even beneficial users of public lands OR are they 1) detrimental usurpers of the floral resources needed by native bees, 2) unreliable pollinators of native plants, and 3) potential spreaders of pathogens to native bees? Some commercial honey beekeepers claim that their honey bees are beyond benign: "They're making more flowers. They're making healthier trees. It could wind up the honeybees are a benefit for public lands. The bees here are creating life. They're not damaging the flowers. By pollinating the flowers in the Forest Service [lands], it ensures a lot of flowers . . ." (https://www.sltrib.com/news/environment/2020/08/23/environmental-groups-want/). (And in their spare time they can substitute for buzzers on TV game shows). Beekeepers seem to have won over federal bureaucrats and land managers to their views because they have succeeded in gaining, practically gratis, the pasturing of commercial honey bee apiaries on public lands. This is occurring in the face of innumerable calls to combat alien species introductions to native ecosystems and much scientific evidence that the answer to the three possibilities posed above is a resounding YES.

How is this happening? Beekeeper applications are being enabled by federal policy (or lack thereof) for apiaries on public lands. Honey bees are being pastured on National Forests and Bureau of Land Management land in Utah and other states without any compliance with the National Environmental Policy Act (1970) which requires that federal agencies assess the environmental effects of their decisions (https://www.epa.gov/nepa). There has never been an Environmental Impact Statement, Environmental Assessment nor an invitation for public input on the effect of apiaries on public lands, all actions required by the Act. Apiaries are being allowed on public lands because honey bees have been treated as a Categorical Exclusion (CE) since at least 1981 though the number of permits requested has been comparatively small until recently. A CE allows bureaucrats and land managers to ignore potential environmental effects. Incredibly, the Forest Service has no record of having even considered the potential effects of apiaries on native ecosystems before granting the CE. The CE designation for apiaries is currently being challenged in a petition filed by four NGOs (non-governmental organizations) including UNPS. A counter petition has also been filed by representatives of the honey bee industry.

There are other reasons beekeepers are being allowed to pasture their bees on public wildlands. Paramount are public policies offered by well-meaning but partially-informed bureaucrats to address honey bee declines. A 2015 White House "Strategy" both publicized the problem of pollinator declines and proposed policies to address it (WHS; https://obamawhitehouse.archives.gov/the-press-office/2014/06/20/presidential-memorandum-creating-federal-strategy-promote-health-honey-b). The WHS, while also acknowledging the decline of native bee species (see, for example, Koh et al. 2016), focused instead on the difficulties confronting populations of monarch butterflies and especially the introduced honey bee. Honey bees have taken precedence over native bees in the WHS because they are viewed as a critical national resource: colonies of these hard-working social wonders that live mostly in commercial hives, are responsible for all of the honey production and most large-scale crop pollination in the U. S. – think almonds, apples, cherries, and a host of other crops. Honey bees also contribute billions of dollars per year to our economy (Durrant 2019) and are backed by an influential lobbying effort. In contrast, native bees have received less attention because they are *merely*

A large apiary photographed along the Twin Creek road in Logan Canyon on the Cache National Forest on 6/20/2020. Photo by David Wallace

responsible for the pollination of our native flora, an ecosystem service that is hard to quantify. Aside from a few NGOs and many scientists there is little support for native bees.

Populations of honey bees are indeed under pressure from numerous factors including the loss of traditional forage lands in the upper Midwest (Otto et al. 2016; Durrant 2019; Durrant & Otto 2019), pesticides, and some as yet to be disentangled mix loosely termed Colony Collapse Disorder (CCD) that includes Varroa plus other mite species, viruses, fungi, bacteria, other arthropods, stress, nutrition and slovenly beekeepers (Steinhauer et al. 2018). However, there are reasons to regard the concern over honey bees as somewhat overstated. Though honey beekeepers have experienced increased rates of loss over the recent decade, the claim that their business is about to go the way of pimples pursued by an airbrush in an image of a fashion model's face is belied by USDA statistics which show that lost colonies have been readily replaced inexpensively by colony splitting and purchasing packaged bees. While this adds additional expenses to beekeeping operations, those expenses have been recouped with higher pollination charges. A recent economic analysis concluded: "We find . . . remarkably little to suggest dramatic and widespread economic effects from CCD" (Rucker et al. 2019a,b). In fact, there has been no appreciable decline in honeybee colony numbers over the past 20+ years (Hellerstein et al. 2017; Rucker et al. 2019a). For the most recent full year reported, Jan. 2019 to Jan. 2020, there was an 8% increase in colony numbers. (Don't take my word for it, just check with the USDA web site: https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Bee_and_Honey/). It is also well to keep in mind that colony loss rates are determined from beekeeper's unverified responses to questionnaires (Steinhauer et al. 2018) and not to any systematic field surveys. The importance of honey bees to our food supply is also somewhat exaggerated. No doubt you've heard that catchy meme that you should thank a bee for one bite of three. Not quite: It's actually

A female *Diadasia diminuta* forages on a *Sphaeralcea* flower. Note the pollen that she has collected in the pollen baskets on her hind legs. This species has a strong preference for globe mallow flowers and will visit other flower genera only under duress.

about one bite in five (Klein et al. 2007), not insignificant but less than the well- publicized estimate. Other's estimates are even lower – a 3 - 8 % reduction in total world agricultural production in the absence of animal pollination (Aizen et al. 2014; Potts et al. 2016). There is also growing evidence that native pollinators contribute to crop pollination under certain circumstances (Garibaldi, et al. 2013) and that roughly 20% of the value of crop pollination is due to bees other than the honey bee (Hellerstein et al. 2017). And finally, another claim, usually credited by media sensationalists to Albert Einstein (as if he hadn't enough trouble trying to reconcile relativity with quantum theory), is that if honeybees went extinct, emaciated humans would soon be crossing the River Styx to Hades. In fact, if humans went extinct my money is on causes other than a lack of honey or almonds. Nevertheless, you should tip your cap to honey bees for the abundance and variety of your diet (Potts et al. 2016). And then there's that multi-billion dollar contribution they make to the U. S. economy. Nuff said: thank you beekeepers, thank you honeybees. As my Yiddish Brooklyn friend might say: *zei gezunt un shtark* (be healthy and strong).

Some of the remedies recommended by the WHS to keep commercial honey bees healthy and strong evoke a potential cascade of unintended consequences for our native flora and the bees that service them. Specifically, the call to pasture commercial hives on public lands administered by the Forest Service and the Bureau of Land Management is extremely worrisome because these wildlands presently serve as the last relatively pristine repository of a large part of the rich native bee fauna of the U. S.: roughly three-quarters of our 4,000+ native bee species occur west of the Mississippi and much of this is on public lands. To use our home state of Utah to illustrate further, there are roughly 1100 documented species of native bees in Utah (one of the four most diverse states for native bee species). A recent study reported >660 bee species in pre-Zinke Grand Staircase-Escalante National Monument (GSENM) alone (Carril et al. 2018); an earlier study (Griswold et al. 1997) recorded 333 species from Utah's San Rafael Desert (SRD), an area roughly one-fifth the size of GSENM. The GSENM and SRD are embedded in other public lands of Utah, and their bee diversity is indicative of that on those lands. So far as we know, many of these species are uncommon or rare globally and locally. This native bee diversity, which is instrumental in pollinating our native flora, is of great value and is at risk. That risk is ecological and is intertwined with ecosystem integrity but unlike honey bee value it is difficult to estimate economically and therefore receives less attention.

Except for bumblebees and a few other species, Utah's bees are not the bees most recognize: some in lofty federal positions confuse them with barflies while many Utahns take them for flies or wasps and call them "meat bees" (for the record, all North American bees are vegetarians). For the most part our species are solitary rather than social. While there may be large nesting aggregations of independent females rearing their offspring alone and without helpmates, there are no hives with thousands of workers (Stephen et al. 1969; Danforth et al. 2019). Species are specialized in their nesting habits: females search for a likely nesting site, some in the ground, others in existing holes in wood or plant stems or, in a few cases, in empty snail shells; sometimes, they build nests using mud or drill out the soft pith of plant stems. Females excavate a burrow, and prepare it with various materials (mud, pulped leaves, small pebbles, resins, etc.). Females collect pollen and nectar, primarily from native plants, and form it into an individual loaf to support the development of each of their offspring. Many species are extremely specialized in the flower species they will visit for pollen (Minckley & Roulston 2006) but not nectar. In most cases, offspring are individually sequestered from mom and from their sibs by partitions, usually made of mud or masticated leaves. Their short adult life span (females typically live 3-4 weeks, males less; they spend most of the year as immatures in the nest) and great investment in parental care of their progeny means that, for insects, they produce few offspring (Neff 2008). Species typically have but one adult generation per year and there is large turnover in species identity over the flowering season (e.g., Griswold et al. 1997).

Predictably, encouraged by WHS and federal land management policy makers, beekeepers are increasingly turning to public lands managed by the Forest Service and the Bureau of Land Management for pasturage. Into these relatively undisturbed high elevation ecosystems beekeepers would introduce staggering numbers of the semi-domesticated, but introduced, honey bee. Of great concern in Utah, for example, is the current request to pasture c. 9000 honey bee hives on four national forests (Manti-La Sal, Fishlake, Dixie, Uintah-Wasatch-Cache) some of which are in close proximity to the species-rich GSENM and SRD. Each of these hives, flush from crop pollination activities mostly on the West Coast, will contain upwards of 30,000 bees, a total of over a quarter of a billion honey bees. Beekeepers have also advised us of their future plans: "We are proposing to put as many apiary sites as possible across different Utah national forests at our researched sites," the manager of the nation's largest commercial beekeeping operation volunteered (https://e360.yale.edu/features/will-putting-honey-bees-on-public-lands-threaten-native-bees). And, importantly, what is being proposed is a yearly 3-4 month incursion of these enormous numbers of honey bees: there are no plans for a respite! Such requests completely ignore the effect on hundreds of species of native bees which will be active during the period when honey bees are usurping floral resources on these forests. And one wonders if Utah is the vanguard for future proposals in other states.

Well, why should honey bees not receive a CE? Isn't their use of the environment non-consumptive, even beneficial? Unfortunately, both honey bees and native bees subsist on the same pollen and nectar from flowers. It has been carefully estimated that a moderately-sized honey bee hive will remove from the environment pollen equivalent to that needed to rear 33,000 average-sized native bees/month (Cane & Tepedino 2017); a single apiary, typically 96 hives strong, would thus remove enough pollen in one month to rear over 3 million native bees. For a three-to-four month period (the length of most permit requests from beekeepers) one apiary would remove enough pollen to rear 9-to-12 million natives. Beekeepers are initially requesting permission to pasture about 90 apiaries or the equivalent in pollen of between 800 million and over a billion native bees on four Utah National Forests! Thus, when WHS policy makers encourage beekeepers to petition public land managers for permission to pasture their bees in summer for honey production they put honey bees and native bees on a collision course and also threaten the seed production of some native plants.

Beekeepers protest such estimates. Indeed, a beekeeper is quoted in a local newspaper article that he believed "the Uinta-Wasatch-Cache National Forest's Logan district can support five times the eight apiaries he is now allowed. Each of his sites has 64 to 96 hives." (https://www.sltrib.com/news/environment/2020/08/23/environmental-groups-want/). Apparently, he was not asked to substantiate such an egregious claim and it's a good thing for him because he would have had more luck proving that honey bees flew back and forth to the North Pole at Christmas to help Santa's reindeer deliver small presents.

To repeat, there are three major reasons why apiaries present a significant threat to native ecosystems, why they should never have been classified as a CE and why such a classification should be dispensed with as soon as possible: 1) competition with native pollinator species; 2) long-term changes in the flora because of honey bee pollination activity; 3) pathogen transmission from honey bees to native bees *and vice-versa*.

A small section of a large nesting site of *Diadasia nitidifrons*, a species with a great fondness for flowers of Iliamna species. Note the chimneys surrounding the nest entrances; no one really understands the purpose of the chimneys (the bees do not light fires in their nests, they have not yet discovered fire).

**Competition**. Our critical concern is competition for pollen because pollen is the primary source of protein and essential nutrients that all bees provide for their progeny and, unlike nectar, it is not renewed by flowers: once an anther dehisces its pollen that's it. A honey bee hive is a much more efficient harvester of pollen and nectar because of its highly developed and coordinated resource detection and foraging system (Winston 1987; Seeley 2009). Scout bees, ever on the lookout for productive flower patches, return to the hive and, through an elaborate communication system, direct numerous prospective forager bees to those pollen- and nectar-rich patches. Female native bees, since they act independently, have no similar capability and have never been challenged by such sophisticated pollen harvesting because no North American bee species has evolved such behavior.

Only if pollen were not limiting, if it were in superabundant supply, could competition not occur when such enormous numbers of honey bees are suddenly introduced to a landscape. What we critically need to know is how much, if any, excess pollen is available in flowers under "normal" circumstances but few such studies have been conducted. Two that have, show little pollen remaining in flowers at day's end when only natives are present, i.e., pollen was a limiting resource to natives before any introduction of honey bees (see Cane and Tepedino 2017 for references). Another carefully planned European study of pollen remaining in large populations of rosemary and thyme flowers in an area (32km$^2$) with 475 hives, found about 34% of rosemary pollen and 46% of thyme pollen remaining in flowers yet concluded that the wild bee community, particularly larger species, was negatively affected by honey bee removal of pollen (Torné-Noguera et al. 2014). Another study provided evidence that honey bee hives in dense clusters compete successfully not only against native bees but also against each other thereby lowering their own resource gathering efficiency (Henry and Rodet 2018).

How might native bees respond to the sudden scarcity of pollen resulting from honey bee foraging? Only two reactions are possible. Native bees may 1) leave the area; or 2) remain and compete. Bees that flee must find areas that have either few or no honey bees. Estimates of the distances natives must fly to escape honey bee hell vary depending on the time of year, total forage available and a host of other factors but given that honey bees from single hives with small numbers of workers can forage over median distances of 6 km (Seeley 2009), that distance could be formidable, particularly for smaller bees with reduced flight ranges (Greenleaf et al. 2007). In other studies, Smart et al. (2016), estimated that apiaries of 48 small hives (10,000 bees/hive) would require a foraging area of 15.5 km$^2$ over the flowering season. Such an estimate should at least be tripled for apiaries on public lands which will have twice as many hives each with three times as many workers. Under these circumstances an escape distance with a radius of 6 km is conservative. And this further assumes that there is no other apiary within 8-16 km, a very unlikely scenario given the numbers of apiaries placement is being sought for. Many native bees would likely die without issue in their attempt to migrate.

What of those native bees that remained? Because of intense honey bee foraging, natives that remained would be forced to visit more flowers to gather a full pollen load and to spend more time out of the nest and expend more energy to do so. Increased time out of the nest would increase exposure to enemies both for foraging females and for their unprotected progeny back in the nest (Goodell 2003). Thus, we would expect increased mortality of philopatric natives, both adult and immature. In addition, other more subtle changes are likely. In general, female bees control both the gender and size of their progeny (Stephen et al. 1969; Danforth et al. 2019). In most species, females are larger than males and require more pollen and nectar to rear. However, when nectar and pollen are in short supply, adult females tend to produce more males and fewer females or smaller offspring than they would under usual circumstances (Bosch 2008). Smaller offspring are less likely to survive over winter (Tepedino and Torchio 1982; Bosch and Kemp 2004) and an excess of male bees simply translates into fewer progeny and smaller populations in subsequent years. Smaller populations, in turn, are under greater risk of local extinction. In addition, many native species only collect pollen from a few plant taxa and will have no alternative forage if they are excluded by honey bees from their preferred plants. Thus, the future of populations of those native bees that remained would be dim: populations, which would be confronted by yearly incursions of large numbers of honey bees, would surely dwindle and die over time thereby creating large areas devoid of many native bee species.

It seriously strains credulity to propose that the sudden introduction of such enormous numbers of pollen-gobbling honey bees could not be detrimental to bees that are native to these mountain ecosystems. Several published articles have reviewed the many past studies of competition between natives and honey bees (e.g., Stout and Morales 2009; Russo 2016; Geslin et al. 2017; Mallinger et al. 2017; Wojcik et al. 2018); generally all report that roughly half of past field studies find evidence of competition. One reason that results are not more conclusive is that competition studies between natives and honey bees are very difficult to conduct with replication under controlled conditions because honey bees have such large foraging ranges and because flower production and thus pollen production fluctuate greatly from year to year as does native bee diversity (Stout and Morales 2009). Finally, generally unmentioned, but of critical importance, is that almost all past studies have been conducted with few hives and with small numbers of bees/hive. As a result, they bear little relevance to current beekeeper requests to pasture many thousands of hives on public lands over an extended number of years. We really have no idea how detrimental the effect will be of acceding to such requests without proper long-term studies.

**Effect on native flora.** The introduction of massive numbers of honey bees will also have unpredictable long term effects on the flora of these mountain ecosystems. Presently, native bees pollinate about 75% of North American flowering plant species (Ollerton et al. 2011) and are, thus, instrumental in maintaining the health of natural wildland habitats and watersheds. The fruits, seeds and leaves of native plants that are consumed by mammals, birds and other wildlife ultimately owe their existence to pollination by native insects, primarily bees. Generally, native bee species are more effective pollinators of the diverse native flora with which they have evolved than are honeybees (Goulson 2003; Dohzono and Yokoyama 2010; Schweiger et al. 2010; Aizen et al. 2014; Aslan et al. 2016; Russo 2016; Magrach et al. 2017; Stanley et al. 2020). Honey bees will pollinate some, but not all, plants as effectively as do native bees and we have no idea which plants will be reproductively disadvantaged and which will not. Nor do we know how such changes in pollination dynamics will change the seed rain, the seed bank and the mix of animals dependent upon fruits and seeds for at least part of their livelihood. In other words, we have no idea how, over time, such alterations will cascade through the ecosystem.

Long-term changes in the flora also will be facilitated by the preference of honey bees for the flowers of some abundant invasive plant species. Numerous studies have shown that weed flowers are favorites of honey bees (Hanley and Goulson 2003; Requier et al. 2015; McMinn-Sauder et al. 2020; Melin et al. 2020) which, in turn, pollinate them and support their spread. As invasive plants spread, they replace native plants and displace the bee species that have entered into tight co-evolutionary relationships with those plants (Stout and Morales 2009). Specialized bees are generally incapable of collecting the pollen of alternative host plants and are at especial risk.

**Pathogen spillover.** There is a long history of pathogen spillover in vertebrate animals and much of it is due to destruction of natural habitat by humans and their thrusting together domestic and wild animals (Cunningham 1996; Daszak et al 2000; Cortezar et al. 2007): we ignore these examples to the peril of both our native bee and honey bee populations. Although research on pathogen spillover between bees is in its infancy, already several studies have shown that pathogens can be passed from honey bees to native bees at flowers and that some of these diseases are debilitating to natives (Tehel et al. 2016). It has been established that honey bees in almond orchards carry a host of pathogens before they are moved into honey production areas (Cavigli et al. 2016; Gisder and Generesch 2017); it is such hives that are intended for movement onto public lands. Other studies have documented the transfer of viruses from honey bees to bumblebees (Singh et al. 2010) and have demonstrated pathogenicity (Fűrst et al. 2014; McMahon et al. 2015). There is also evidence that other viruses have been transferred from honey bees to several genera of native bees (*Ceratina, Andrena, Anthophora, Osmia, Xylopcopa*; Radzevîĉiüte et al. 2017; Santamaria et al. 2018) and that these viruses replicate in those bee taxa.

Conversely, native bees carry a variety of pathogens to which honey bees, currently under pressure from various disease agents may be susceptible (Singh et al. 2010). New reports of potential native bee pathogens are appearing frequently (e.g., Murray et al. 2019; Graystock et al. 2020). We can ill afford to introduce such novel pathogens into honey bee populations when we are ignorant of their potential effect. It is hard to comprehend why honey beekeepers are willing to further risk the health of their industry by exposing their living capital to potential diseases carried by natives. This is especially perplexing because in the 1980s honey bee keepers, at the time experiencing significant losses due to the fungal disease chalkbrood, were quick to blame the solitary species *Megachile rotundata*, the alfalfa leafcutter bee, as the carrier of the disease; purportedly, it was spreading chalkbrood to honey bees in alfalfa fields. It wasn't but one does wonder how beekeepers could so quickly forget.

**Resolution**. Agreement on the honey bee-native bee issue can best be addressed if we agree that: 1) honey beekeepers require summer forage for their bees. Summer is the time when beekeepers switch from pollination services to honey production, both for additional income (roughly 55-60% of their revenue comes from honey; Hellerstein et al. 2017) and to allow bees to accumulate honey for the winter. And 2) public land managers have as one their primary objectives the preservation of biodiversity and the maintenance of ecosystem integrity. The question then becomes where honey bee hives are to be pastured in the summer and whose responsibility it is to provide that pasture. The resultant problem was summed up concisely by Durrant (2019): "Beekeepers are subject to exclusionary forces in part because they do not own the land they need for production in the United States. Thus, they are constantly vulnerable to land management decisions made by land owners and land managers on public lands." For the most part, beekeepers have never used their own lands for summer forage for their bees: they have always depended upon the flowers of strangers (with apologies to Blanche DuBois and Tennessee Williams); they have pastured their bees on or adjacent to the lands of cooperative landowners and repaid that privilege nominally (Nordhaus 2011; Hellerstein et al. 2017; Rucker et al. 2019). Tradition and inertia die hard. Beekeepers are now in a pickle because private forage land has become scarce for economic reasons (see below). "Society" must now decide, through our representatives in congress and in federal agencies, whether we want to subsidize beekeepers by allowing them on public lands in summer, thereby impacting native species, or if alternative measures can be devised.

The need for pastureland on which to produce honey was recognized by the WHS which enlisted action by several federal agencies and made numerous proposals to reverse bee decline, including: "restore or enhance 7 million acres of land for pollinators (including the monarch butterfly) over the succeeding five years through federal actions and public/private partnerships." Important programs for the addition of those 7 million acres include, but are not limited to, the Conservation Reserve Program (CRP) and Environmental Quality Incentives Program (EQIP) of

USDA. EQIP provides support to farmers and ranchers to implement practices to provide wildlife habitat and food sources for honeybees. Participation in the EQIP program to improve fish and wildlife and pollinator habitat declined from 14.9 million acres in 2009 to 9.9 million acres in 2016. The largest program, CRP, which actually began in 1985, compensates farmers, mostly in the Midwest, to convert fragile or environmentally sensitive cropland to wildlife and pollinator habitat for 10-15 years. Unfortunately, participation by farmers and landowners in CRP has declined by 13 million acres to 23.5 million acres because they can realize a greater profit by putting their land into biofuel crops such as corn, which is of no value to beekeepers, and soybean, some varieties of which may provide nectar and are attractive to bees but are heavily sprayed with pesticides (Otto et al. 2018; Durrant and Otto 2019). Such declines are particularly onerous in the Midwest where over 50% of honeybee colonies have traditionally spent their summers producing honey in the Northern Great Plains (the Dakotas, Minnesota, eastern Montana, and other states). In addition, much of the CRP land envisioned for pollinators, the CP42 program, was undersubscribed (only 1.4% of total CRP land went into CP42 because the cost was 3-4 times greater than the grassland option; Hellerstein et al. 2017).

If we have decided that subsidizing the honey beekeeping industry is in the best interests of society, then changes in federal programs will be necessary to increase the caps on eligible lands and to increase landowner participation. The recent Farm Bill increase in the statutory cap on the land area available for CRP participation to 27 million acres by 2022 is a positive step but is not nearly as large as that recommended to fully address the issue (Otto et al. 2018). Another positive step would be to subsidize those landowners willing to enroll in CP42 for the difference in the additional cost they must incur to prepare their land for pollinators rather than grassland. Other steps to encourage full subscription by farmers and ranchers to extant programs need to be developed. WHS also directed other federal agencies to take steps to provide pollinator habitat. For example, floral enrichments on military base margins, utility corridors, Army Corps of Engineer Projects and even airports could also expand acreage for summering apiaries of U.S. migratory beekeepers. Follow ups on these programs are needed to evaluate their efficacy. Other recommendations for habitat enhancements for pollinators on farmland can be found in Burkle et al. (2013) and Kovács-Hostyánszki et al. 2017).

Finally, there is also room for beekeepers to become more creative in providing for their little money-makers. Perhaps it is time to for them to explore mid-summer cooperative agreements with farmers wherein farmers plant and profit from nectar-rich oilseed crops such as those being investigated in Minnesota (Thom et al. 2016) and beekeepers pollinate those crops gratis while profiting from the honey. To quote Thom et al. (2016): "by integrating specialty oilseeds into Northern Corn Belt cropping systems on highly productive lands we can increase exponentially the availability of rich floral resources . . . Such a change would be a boon for both pollinators and producers." Sounds like it's worth a try to me. Beekeepers, what do you think?

We began this inquiry with a straightforward question: Are honey bees likely to be benign, beneficial or detrimental users of public lands? The scientific evidence, such as it is, suggests that honey bees are a detriment to native bees and some of the plants they pollinate. Although it is hard to quibble with the potential for pathogen spillover and its attendant dangers, some might object that the evidence for competitive displacement of native bees is mixed: it is. It is mixed for several reasons: 1) it is difficult to conduct meaningful, controlled and replicated studies of competition between honey bees and the native bee community on wildlands because of the ambit of honey bee foraging and the diversity of the native bee community; some studies are better than others at addressing this problem; 2) most studies are conducted using hive and bee numbers that are miniscule compared to current beekeeper requests and yet they find evidence of competition; 3) no study of which I am aware looks at the prolonged effect of yearly introductions of apiaries yet this is what is being requested by beekeepers. To what logical conclusion are we driven if some small scale, temporally-limited studies uncover evidence of competition and beekeeper requests are for sustained yearly introductions of honey bee numbers that are orders of magnitude larger than any study thus far conducted?

To continue to treat honey bee usage of public lands as a CE without even considering these valid objections is to invite long-term ecological transformation of these high mountain landscapes. The CE designation for honey bees should be rescinded immediately pending the result of an EIS: honey bees should be kept off public lands in these enormous numbers until we have a better understanding of the risk their presence raises. To help resolve this issue we should commission well-designed studies of pollen limitation in ecosystems without honey bees present. Is it possible that the enormous amounts of excess pollen needed to feed honey bees is available? Unlikely, but then we don't know. And finally, we need to estimate the risk to bees by supporting studies of pathogen spillover.

And what of the legitimate plight of the honey bee? That plight can only be addressed by a combination of expansion and modification of government programs such as CRP, EQIP, etc., and the creation of new private partnerships between beekeepers and farmer/ landowners. Perhaps the government has a role in bringing such prospective collaborators together. But to address honey bee plight by allowing beekeepers to flood public lands with apiaries is to try to cure one problem while creating another. And when the potential for pathogen spillover is stirred into the pot the law of unintended consequences can cook up a noisome soup not on the menu at Chez Panisse. •

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Bio: The author began studying bees professionally 46 years ago after migrating (but not due to displacement by honey bees) from Brooklyn to Wyoming and then to Utah. He retired from a pollen-rich position in 2004 but continues to forage on bee conservation and ecology issues. He may be reached for civil comments/questions at: Tepadasia@aggiemail.usu.edu

Citations

Aizen, M.A., C.L. Morales, D.P. Vázquez, L.A. Garibaldi, A. Sáez, A. and L.D.Harder. 2014. When mutualism goes bad: density-dependent impacts of introduced bees on plant reproduction. *New Phytologist*, *204*(2), pp.322-328.

Aslan, C.E., C.T. Liang, B. Galindo, H. Kimberly, and W. Topete. 2016. The role of honey bees as pollinators in natural areas. *Natural Areas Journal*, *36*(4): 478-488.

Bosch, J. 2008. Production of undersized offspring in a solitary bee. *Animal Behaviour 75*(3):.809-816.

Bosch, J. and W.P. Kemp. 2004. Effect of pre-wintering and wintering temperature regimes on weight loss, survival, and emergence time in the mason bee *Osmia cornuta* (Hymenoptera: Megachilidae). *Apidologie*, *35*(5): 469-479.

Cane, J.H. and V. J. Tepedino. 2017. Gauging the effect of honey bee pollen collection on native bee communities. *Conservation Letters*, *10*(2): .205-210.

Carril, O.M., T. Griswold, J. Haefner, and J.S. Wilson. 2018. Wild bees of Grand Staircase-Escalante National Monument: richness, abundance, and spatio-temporal beta-diversity. *PeerJ*, *6*, p.e5867.

Cavigli, I., K.F. Daughenbaugh, M. Martin, M., Lerch, K. Banner, E. Garcia, L.M. Brutscher, and M.L. Flenniken. 2016. Pathogen prevalence and abundance in honey bee colonies involved in almond pollination. *Apidologie*, *47*: 251-266.

Cunningham, A.A., 1996. Disease risks of wildlife translocations. *Conservation biology*, *10*(2): 349-353.

Danforth, B.N., R. L. Minckley, J.L., Neff, and F. Fawcett. 2019. *The solitary bees: biology, evolution, conservation*. Princeton University Press.

Daszak, P., A.A. Cunningham, and A.D. Hyatt. 2000. Emerging infectious diseases of wildlife--threats to biodiversity and human health. *Science*, *287*(5452): 443-449.

Dohzono, I. and J. Yokoyama. 2010. Impacts of alien bees on native plant-pollinator relationships: A review with special emphasis on plant reproduction. *Applied Entomology and Zoology*, *45*(1): 37-47.

Durant, J.L. 2019. Where have all the flowers gone? Honey bee declines and exclusions from floral resources. *Journal of Rural Studies 65*: 161-171.

Durant, J.L. and C. R. Otto. 2019. Feeling the sting? Addressing land-use changes can mitigate bee declines. *Land Use Policy*, *87*: 104005 (1-8).

Fürst, M.A., D.P.McMahon, J.L. Osborne, R.J. Paxton, and M.J.F. Brown. 2014. Disease associations between honeybees and bumblebees as a threat to wild pollinators. *Nature*, *506*(7488): 364-366.

Garibaldi, L.A., I. Steffan-Dewenter, R. Winfree, M.A. Aizen, R. Bommarco, S.A. Cunningham, C. Kremen, L.G.Carvalheiro, L.D. Harder, O. Afik, O. and I. Bartomeus. 2013. Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *Science 339*(6127):1608-1611.

Geslin, B., B. Gauzens, M. Baude, I. Dajoz, C. Fontaine, M. Henry, I. Ropars, O. Rollin, E. Thébault, and N.J. Vereecken. 2017. Massively introduced managed species and their consequences for plant–pollinator interactions. In *Advances in Ecological Research* 57: 147-199.

Gisder, S. and E. Genersch. 2017. Viruses of commercialized insect pollinators. *Journal of Invertebrate Pathology*, *147*: 51-59.

Goodell, K. 2003. Food availability affects Osmia pumila (Hymenoptera: Megachilidae) foraging, reproduction, and brood parasitism. *Oecologia*, *134*: 518-527.

Goulson, D., 2003. Effects of introduced bees on native ecosystems. *Annual Review of Ecology, Evolution, and Systematics*, *34*(1): 1-26.

Gortázar, C., E. Ferroglio, U. Höfle, K. Frölich, and J. Vicente. 2007. Diseases shared between wildlife and livestock: a European perspective. *European Journal of Wildlife Research*, *53*(4): 241.

Graystock, P., W.H. Ng, K. Parks, A.D. Tripodi, P.A. Muñiz, A.A. Fersch, C.R. Myers, Q.S. McFrederick, and S.H. McArt. 2020. Dominant bee species and floral abundance drive parasite temporal dynamics in plant-pollinator communities. *Nature Ecology & Evolution*, *4*(10), pp.1358-1367.

Greenleaf, S.S., N.M. Williams, R. Winfree, and C. Kremen. 2007. Bee foraging ranges and their relationship to body size. *Oecologia*, *153*(3): 589-596.

Griswold, T., F. D. Parker, and V. J. Tepedino. "The bees of the San Rafael Desert: implications for the bee fauna of the Grand Staircase-Escalante National Monument." In *Learning from the Land, Biology Section. Grand Staircase-Escalante National Monument Science Symposium Proceedings, Cedar City, Utah*. 1997; pp. 175-186.

Hanley, M.E. and D. Goulson. 2003. Introduced weeds pollinated by introduced bees: Cause or effect?.*Weed Biology and Management 3*(4): 204-212.

Hellerstein, D., C. Hitaj, D. Smith, and A. Davis. 2017. *Land use, land cover, and pollinator health: A review and trend analysis.* Economic Research Service Report No. 232. https://ageconsearch.umn.edu/record/263074/

Henry, M. and G. Rodet. 2018. Controlling the impact of the managed honeybee on wild bees in protected areas. *Scientific reports*, *8*(1): 1-10.

Klein, A.M., B. E. Vaissiere, J. H. Cane, I. Steffan-Dewenter, S. A. Cunningham, C. Kremen and T. Tscharntke. 2007. Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B: Biological Sciences*, *274*(1608): 303-313.

Koh, I., E. V. Lonsdorf, N. M. Williams, C. Brittain, R. Isaacs, J. Gibbs, and T. H. Ricketts. 2016. Modeling the status, trends, and impacts of wild bee abundance in the United States. *Proceedings of the National Academy of Sciences*, *113*(1): 140-145.

Magrach, A., J.P. González-Varo, M. Boiffier, M. Vilà, M. and I. Bartomeus. 2017. Honeybee spillover reshuffles pollinator diets and affects plant reproductive success. *Nature Ecology & Evolution*, *1*(9); 1299-1307.

Mallinger, R.E., H.R. Gaines-Day, and C. Gratton. 2017. Do managed bees have negative effects on wild bees? A systematic review of the literature. *PloS one*, *12*(12), p.e0189268.

McMahon, D.P., M.A. Fürst, J. Caspar, P. Theodorou, M.J. Brown, and R.J. Paxton. 2015. A sting in the spit: widespread cross-infection of multiple RNA viruses across wild and managed bees. *Journal of Animal Ecology*, *84*(3): 615-624.

McMinn-Sauder, H., R. Richardson, T. Eaton, M. Smith, and R. Johnson. 2020. Flowers in Conservation Reserve Program (CRP) Pollinator Plantings and the Upper Midwest Agricultural Landscape Supporting Honey Bees. *Insects*, *11*(7), p.405.

Melin, A., J.F. Colville, G.D. Duckworth, R. Altwegg, R. Slabbert, J.J. Midgley, M. Rouget, M. and J. S Donaldson. 2020. Diversity of pollen sources used by managed honey bees in variegated landscapes. *Journal of Apicultural Research*, pp.1-12.

Minckley, R.L. and Roulston, T.H., 2006. Incidental mutualisms and pollen specialization among bees. In: *Plant-pollinator interactions: from specialization to generalization*, N.M. Waser, and J. Ollerton (eds.),pp.69-98. Univ. of Chicago Press, Chicago IL

Murray, E.A., J. Burand, N. Trikoz, J. Schnabel, H. Grab, H. and B.N. Danforth. 2019. Viral transmission in honey bees and native bees, supported by a global black queen cell virus phylogeny. *Environmental Microbiology*, *21*: 972-983.

Neff, J.L., 2008. Components of nest provisioning behavior in solitary bees (Hymenoptera: Apoidea). *Apidologie*, *39*(1), pp.30-45.

Nordhaus, H.  2011. The beekeeper's lament. Harper, New York

Ollerton, J., R. Winfree, and S. Tarrant. 2011. How many flowering plants are pollinated by animals?. *Oikos*, *120*(3): 321-326

Otto, C.R., C.L. Roth, B.L. Carlson, and M.D. Smart. 2016. Land-use change reduces habitat suitability for supporting managed honey bee colonies in the Northern Great Plains. *Proceedings of the National Academy of Sciences*, *113*(37), pp.10430-10435.

Otto, C.R., H. Zheng, A.L. Gallant, R. Iovanna, B.L. Carlson, M.D. Smart, and S. Hyberg. 2018. Past role and future outlook of the Conservation Reserve Program for supporting honey bees in the Great Plains. *Proceedings of the National Academy of Sciences*, *115* (29): 7629-7634.

Potts, S.G., Biesmeijer, J.C., Kremen, C., Neumann, P., Schweiger, O. and Kunin, W.E., 2010. Global pollinator declines: trends, impacts and drivers. *Trends in ecology & evolution*, *25*(6), pp.345-353.

Potts, S.G., V. Imperatriz-Fonseca, H.T. Ngo, M.A. Aizen, J.C. Biesmeijer, T.D. Breeze, L.V. Dicks, L.A. Garibaldi, R. Hill, J., Settele, and A.J. Vanbergen. 2016. Safeguarding pollinators and their values to human well-being. *Nature*, *540*(7632), pp.220-229.

Radzevičiūtė, R., P. Theodorou, M. Husemann, G. Japoshvili, G., Kirkitadze, A. Zhusupbaeva, A. and R. J. Paxton. 2017. Replication of honey bee-associated RNA viruses across multiple bee species in apple orchards of Georgia, Germany and Kyrgyzstan. *Journal of Invertebrate Pathology 146*: 14-23.

Requier, F., J.F. Odoux, T. Tamic, N. Moreau, M. Henry, A. Decourtye, and V. Bretagnolle. 2015. Honey bee diet in intensive farmland habitats reveals an unexpectedly high flower richness and a major role of weeds. *Ecological Applications*, *25*(4): 881-890.

Rucker, R.R., W.N. Thurman, and M. Burgett. 2019a. Colony Collapse and the Consequences of Bee Disease; Market Adaptation to Environmental Change. Journal of the Association of Environmental and Resource Economists 6(2019): 927–960.

Rucker, R.R., W.N. Thurman, and M. Burgett. 2019b. Honey Bee Mortality, Markets, and the Food Supply. *Choices*, *34*(316-2019-4159): 1-9.

Russo, L. 2016. Positive and negative impacts of non-native bee species around the world. *Insects 7*(4), 69.

Santamaria, J., E.M. Villalobos, L.E. Brettell, S. Nikaido, J.R. Graham, and S. Martin. 2018. Evidence of Varroa-mediated deformed wing virus spillover in Hawaii. *Journal of Invertebrate Pathology*, *151*: 126-130.

Schweiger, O., J.C. Biesmeijer, R. Bommarco, T. Hickler, P.E. Hulme, S. Klotz, I. Kühn, M. Moora, A. Nielsen, R. Ohlemüller, and T. Petanidou. 2010. Multiple stressors on biotic interactions: how climate change and alien species interact to affect pollination. *Biological Reviews*, *85*(4): 777-795.

Seeley, T.D., 2009. *The wisdom of the hive: the social physiology of honey bee colonies*. Harvard University Press.

Singh, R., A.L.Levitt, E.G. Rajotte, E.C. Holmes, N. Ostiguy, W.I. Lipkin, C.W. dePamphilis, A.L. Toth, and D.L. Cox-Foster. 2010. RNA viruses in hymenopteran pollinators: evidence of inter-taxa virus transmission via pollen and potential impact on non-*Apis* hymenopteran species. *Plos one*, *5*(12), p.e14357.

Smart, M., J. Pettis, N. Rice, Z. Browning, and M. Spivak. 2016. Linking measures of colony and individual honey bee health to survival among apiaries exposed to varying agricultural land use. *PloS one*, *11*(3), p.e0152685.

Stanley, D.A., S.M. Msweli, and S.D. Johnson. 2020. Native honeybees as flower visitors and pollinators in wild plant communities in a biodiversity hotspot. *Ecosphere*, *11*(2), p.e02957.

Steinhauer, N., K. Kulhanek, H. Antúnez, P. Human, P. Chantawannakul, and M. P. Chauzat, 2018. Drivers of colony losses. *Current Opinion in Insect Science*, *26*:142-148.

Stephen, W.P., G. E. Bohart, and P. F. Torchio. 1969. The Biology and External Morphology of Bees with a Synopsis of the Genera of North-western America. Agricultural Experiment Station, Oregon State University, Corvallis OR. https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1107&context=piru_pubs

Stout, J. C. and C. L. Morales. 2009. Ecological impacts of invasive alien species on bees. Apidologie 40: 388-409.

Tehel, A., M.J. Brown, and R.J. Paxton. 2016. Impact of managed honey bee viruses on wild bees. *Current Opinion in Virology 19:* 16-22.

Tepedino, V.J. and P.F. Torchio. 1982. Phenotypic variability in nesting success among Osmia lignaria propinqua females in a glasshouse environment:(Hymenoptera: Megachilidae). *Ecological Entomology*, *7*(4), pp.453-462.

Thom, M.D., C.A. Eberle, F. Forcella, R. Gesch, S. Weyers, and J.G.Lundgren. 2016. Nectar production in oilseeds: food for pollinators in an agricultural landscape. *Crop Science*, *56*(2): 727-739.

Torné-Noguera, A., A. Rodrigo, S. Osorio, and J. Bosch. 2016. Collateral effects of beekeeping: Impacts on pollen-nectar resources and wild bee communities. *Basic and Applied Ecology 17*(3): 199-209.

Winston, M.L.1991. *The biology of the honey bee*. Harvard University Press.

Wojcik, V.A., L.A. Morandin, L. Davies Adams, and K.E Rourke. 2018. Floral resource competition between honey bees and wild bees: is there clear evidence and can we guide management and conservation? *Environmental Entomology*, *47*(4): 822-833.