Should we move the whitebark pine? Assisted migration, ethics, and global environmental change

Clare Palmer[1] and Brendon M. H. Larson[2]

Abstract

Some species face extinction if they are unable to keep pace with climate change. However, proposals to assist threatened species' poleward or uphill migration ('assisted migration') have caused significant controversy among conservationists, not least because assisted migration seems to threaten some values, even as it protects others. To date, however, analysis of ethical and value questions about assisted migration has largely remained abstract, removed from the ultimately pragmatic decision about whether or not to move a particular species. This paper uses a case study of the whitebark pine, a keystone species of sub-alpine habitats in western North America, to consider how particular cases of assisted migration may be approached ethically. After taking into account the value of species, wildness, place, ecosystems, culture, and sentient animals, we conclude that, on balance, there appears to be good reasons to move the whitebark pine.

Keywords

Assisted migration, ecosystem values, place values, sentience, wildness, whitebark pine

Introduction

Climate change will have numerous and significant effects on wild organisms, species and ecosystems due to changing temperature and precipitation regimes, rising sea-levels and melting ice. Species are already moving upward and poleward in response to warming temperatures: based on a global meta-analysis, Parmesan and Yohe (2003: 37) document 'significant range shifts averaging 6.1 km per decade towards the poles (or metres per decade upward)'. As average global temperatures warm, this process is

[1] Department of Philosophy, Texas A&M University, 4237 TAMU, College Station, TX 77843-4237, USA

[2] Department of Environment and Resource Studies, University of Waterloo, Waterloo, ON N2L 3G1, Canada

expected to continue. However, many species will be unable to relocate themselves. They are therefore at risk of extinction, especially where factors such as disease and habitat loss exacerbate the effects of climate change.

Avoiding such species extinctions motivates recent proposals that people should deliberately assist certain species threatened by climate change to move to new habitat, beyond their historical range, that they otherwise could not reach. This practice is called *assisted migration*, though other terms for essentially the same practice include 'managed relocation' (Richardson et al. 2009, Schwartz et al. 2012) and 'assisted colonization' (Hunter 2007). There are already several cases where species have been relocated partly on account of climate change, including the conifer *Torreya taxifolia*, in the US, and marbled white and small skipper butterflies in the U.K. (McLachlan et al. 2007 and Willis et al. 2009, respectively).

Assisted migration is, essentially, a value-driven practice, as recent accounts have made clear (e.g., McCoy and Berry 2008, Camacho 2010, Minteer and Collins 2010, Sandler 2010, Aubin et al. 2011, Schwartz et al. 2012). The primary reason usually offered in support of assisted migration proposals is to maintain valued species in the face of climate change (for all of the reasons species are usually valued). But assisted migration has also attracted significant opposition, opposition that is also value-driven. These objections focus on the potential for negative impacts on valuable recipient ecosystems and species in those systems, and on doubts that assisted migration will actually protect the values for which it's being carried out. Sandler (2013: 9), for instance, argues that 'trying to preserve species by moving them to new ecosystems is very rarely justified' while Ricciardi and Simberloff (2008) argue that, because of the risks that migrated species pose to existing valuable ecosystems, and its potential to distract from habitat conservation, assisted migration should not be carried out at all.

In this paper, we hope to contribute to this debate about ethics, values and assisted migration by focusing on a single case study: that of the whitebark pine, a current candidate species for assisted migration. Although other general papers on ethics and

assisted migrations use case studies illustratively (in particular Albrecht et al. 2013), none has made the examination of a particular case its primary focus. We consider this case-based approach to be a useful complement to existing more general, theoretical ethical arguments, and recently proposed decision-making frameworks (e.g., Hoegh-Guldberg et al. 2008, Richardson et al. 2009). Our approach is consistent with Minteer and Collins' (2010: 1803) recommendation that:

> What is needed … is the development of a more pragmatic ethics of species relocation under climate change. This … should be less preoccupied with whether such efforts should be undertaken in the abstract. The attention should shift to outlining the conditions under which managed relocation should be considered as a realistic option and what criteria are relevant to distinguishing "good" from "bad" relocation proposals and evaluating good and bad relocation efforts on the ground.

We suggest that looking at a particular case 'on the ground' may bring to light particular values at stake—perhaps relevant to other cases—that a more generalized, 'top-down' approach might miss. And, in addition, future discussions of assisted migration are surely going to have to work on a case-by-case basis. With a very few exceptions (perhaps including Ricciardi and Simberloff 2008) virtually everyone agrees that there will be at least some cases in which assisted migration can be justified ethically (and is economically feasible), although they disagree as to whether these cases may be rather rare, as Sandler (2010, 2013) suggests, or relatively common. But if there is neither general *rejection* of the practice, nor general *justification* for it, then potential candidates for assisted migration will have to be assessed individually. If this is right, then we need to think about how best to approach such individual cases, and what factors should be taken into account in decision-making about them. And while value/ethical questions are not *all* that's at issue (obviously, economic questions will be significant too) they are certainly very important.

This paper, then, by using a single case study, attempts to provide a modest and preliminary initial example of a case-based approach to the ethics of assisted migration.

We recognize that working with cases can be problematic, in particular because they are inevitably selective in terms of what is and is not emphasized, and alternative narratives of the same case are possible (see Pattison et al. 1999 for further discussion). We do not attempt to make strong generalizable claims about how our conclusions from this case can be transferred to other cases where assisted migration is being proposed (in fact, whitebark pine has some unusual features that would make it a difficult case from which to generalize). Our aims are, first, to consider whether we should relocate the whitebark pine—concluding that there are, on balance, good reasons to do so—and, second, to provide what we hope is a useful example of how, from an ethical perspective, particular cases of assisted migration may be approached. In particular, in this regard, we incorporate consideration of several values that have not previously been much addressed in the literature on assisted migration.

Whitebark Pine: Context and Threats

The whitebark pine (*Pinus albicaulis*, Figure 1) is a widespread species of subalpine and treeline habitats of western North America. It is often considered a keystone species because its seeds are an important food source for montane species, including overwintering grizzly bears; it regulates runoff by inhibiting snowmelt; and, as a 'foundation' species, it can create conditions for other plant species to germinate and grow at high elevations (Fish and Wildlife Service 2011b). Whitebark pine has very large, wingless seeds, and depends on a specialized mutualist relationship with a bird, the Clark's Nutcracker (*Nucifraga columbiana*), for dispersal. The birds extract whitebark pine seeds from cones, transport them, and cache them, at an average depth of 2-3cm, for later consumption (Hutchins and Lanner 1982, Tomback 1982, McKinney et al. 2009). While Clark's Nutcrackers can and do eat the seeds of other pines, and emigrate in 'irruptions' to different areas if local whitebark pines have an inadequate cone crop to support them, the mutualism is obligate for the whitebark pine, which has no significant alternative seed disperser. Its seeds usually successfully germinate only from uneaten nutcracker caches, one to three summers after a cone crop, often producing multi-stemmed trees from seeds cached together (McLane and Aitken 2012).

Figure 1. A whitebark pine (*Pinus albicaulis*) on a rocky ridge in the Targhee National Forest in western Wyoming, on the west edge of Grand Teton National Park. Photo courtesy of and copyright of Cyndi Smith.

In the past few decades, numbers of whitebark pines have plummeted: over 50% of trees are deceased or dying (McLane and Aitken 2012). The major cause of this decline is white pine blister rust (*Cronartium ribicola*; WPBR), caused by an invasive fungal pathogen. It is now found through nearly the whole range of the whitebark pine, killing 90% of trees in some locations (e.g., Smith et al. 2013). A few trees seem to have resistance, and there is lower mortality despite similar infection rates at higher elevations, perhaps because of a shorter growing season (Smith et al. 2013). A second threat to the whitebark pine is increasing mortality from mountain pine beetle (*Dendroctonus ponderosae*), which prefer trees weakened by WPBR. Where WPBR or pine beetles are active, trees are killed and cone production is reduced. This disrupts nutcracker seed dispersal because 'a threshold level of ~1000 cones/ha is needed for a high likelihood of seed dispersal by nutcrackers' (McKinney et al. 2009: 597). Disruption of nutcracker dispersal means that whitebark pine regeneration is low, raising concerns about the long-term viability of populations. A third threat to the whitebark pine has come from direct human activity: the suppression of low-intensity natural fires. Whitebark pine is fire-tolerant, but its competitors, such as subalpine fir and Engelmann spruce, are not; so they thrive at its expense where fires are suppressed (Cox 2000).

The situation for the whitebark pine is, then, already very precarious. However, climate change will exacerbate these problems (Fish and Wildlife Service 2011b). First, it's likely that epidemic outbreaks of mountain pine beetle are already more common due to a warming climate—and increasing, both because there are reduced cold periods that kill the beetles, and because of a shift in the beetles' natural history from a 2-year life cycle (semivoltine) to a 1-year life cycle (univoltine) (Logan and Powell 2001, Fish and Wildlife Service 2011b). Second, although whitebark pine is fire tolerant, it may also be

more susceptible to more extreme fires expected with climate change (Smith et al. 2013). Third, and most significantly, the temperature envelope within which whitebark pine can flourish is expected to shift significantly northwards (Figure 2). Species distribution models (SDMs), for example, predict that

> whitebark pine will need to migrate hundreds of kilometers over the next century in response to climate change … The species is projected to lose 73% of its current climatic range within British Columbia (BC), Canada by 2085, while gaining an equivalent-sized new climatic range northwest of its current northern range limit. Simultaneously, the species is projected to lose >97% of its current climatic niche within the United States (McLane and Aitken 2012: 143).

Figure 2. The current observed range of whitebark pine in northwestern North America (but not farther south in the United States) and its predicted range in British Columbia in 2055 based on Species Distribution Models (from McLane and Aitken 2011). The map also includes the current range limit of the Clark's Nutcracker (*Nucifraga columbiana*), derived from Campbell et al. (1997) and FAN (2007); we are unaware of any predictions of its future distribution, so this map provides a conservative estimate of its future overlap with the whitebark pine.

Although there are always uncertainties associated with such models (and climate change models, more generally), the Fish and Wildlife Service (2011a) nonetheless determined recently that the whitebark pine 'warrants protection under the Endangered Species Act' although it lacked sufficient priority (in comparison with other species) actually to be added to the Federal List. In Canada, a 13-year monitoring program in the Canadian Rockies found a 3% annual increase in mortality (Smith et al. 2013), and the species is now listed provincially (in Alberta, Government of Alberta 2012) and federally (Government of Canada 2012) as endangered.

Assuming (for now; we will return to this question) that protecting the whitebark pine species is an appropriate conservation goal, what strategies are available for protecting it?

Protecting the Whitebark Pine: Possible Strategies

The most conservative strategy for protecting the whitebark pine is to allow natural low intensity fires to burn, and to carry out prescribed burns in its core habitat. This will remove competitor species, and encourage nutcrackers, who prefer open areas for seed caching, probably because of a lower rate of seed predation (Hutchins and Lanner, 1982). Such practices should allow for increased whitebark pine regeneration. An additional possibility is to fell competitor species within 10km of whitebark pine seed sources; the open areas should attract nutcrackers to cache and also encourage natural regeneration. However, given the multiplicity of threats facing whitebark pine, prescribed burns and the felling of competitor trees alone is unlikely to prevent further population decline (McKinney et al. 2009; McLane and Aitken 2012).

A more comprehensive strategy combines these practices with the development of rust-resistant whitebark pine seedlings in nurseries (McKinney et al. 2009) and their restorative planting. Experimental planting of seedlings from apparently more rust-resistant stands of whitebark pine are currently under way and may succeed in re-establishing whitebark pine in some areas where it's currently threatened. However, the species takes about 30-50 years to begin producing cones, and several decades more to produce significant seed crops, giving an estimated generation time of at least 60 years (COSEWIC 2010). By the time these rust-resistant trees have themselves reached reproductive maturation, we can expect fairly substantial warming to have occurred, so at least some of them will be located outside the climate envelope for whitebark pine. If McLane and Aitken (2012) are right, in 60-80 years, when these trees would be in their reproductive prime, almost all of their current climatic niche in the US will be lost.

These concerns underpin the suggestion that assisted migration will be the most effective strategy for the long-term preservation of the whitebark pine. In principle at least, if rust resistant seeds or seedlings could be moved farther north, this cooler environment could

protect the whitebark pine from both the effects of climate change and more active mountain pine beetle. This does, however, raise the question of why the movement of whitebark pine *needs* to be assisted: why is it not moving north of its own accord, given that climate is already changing, and there is no obvious natural or anthropogenic barrier to its doing so?

One possible answer is that whitebark pine cannot survive farther north, perhaps because appropriate mycorrhizal fungi are absent there (COSEWIC 2010). Species Distribution Models, however, suggest that the whitebark pine could currently occupy a much more extensive range than it actually does. This suggests either a distribution problem (the whitebark pine seeds aren't *getting* there), a survival problem (the seeds are getting there, but are not reaching maturity), or that the SDMs are incorrect (which is not unlikely given the challenges in applying regional models at a more local scale amidst the microtopographical variability in montane habitats).

McLane and Aitken (2012) set out to test the SDMs and experimentally determine whether whitebark pine could survive beyond its current range. They collected seeds from seven sources (provenances) and planted them in eight locations, two within the current range and six elsewhere, predicted to be 'habitable for whitebark pine under current and 2055 climate conditions' (144). These locations spanned 'nearly 10° latitude, from 600 km southeast to 800 km northwest of the current northern range margin' (145). In all locations, seeds germinated and seedlings survived for the first three growing seasons. Although three years of growth for a tree that takes more than ten times that to reach reproductive maturity is a short time, it at least suggests that whitebark pine might survive—at least, rust-resistant strains might survive—if planted much farther north, well outside its current range. This experiment also suggests that whitebark pine is not currently found farther north due to a problem of distribution rather than survival.

If the problem is one of distribution, then the follow-up question concerns why Clark's Nutcrackers have not already moved whitebark pine farther north (see Figure 2). We don't know the answer to this question, though there are 'relatively high WPBR infection

levels (49%) near the northern limit of whitebark pine' and these 'may have implications for natural migration latitudinally' (Smith et al. 2013: 95). If the northern edge of whitebark pine is low-cone producing, then nutcrackers won't be caching nearby. There is a more straightforward answer to why the whitebark pine is not moving up in *altitude*: at higher altitudes than the tree is currently found (it is a treeline species) the restricting factor is not so much cold or snow, which might lessen with climatic warming, but an absence of soil. Since sufficient soil is unlikely to accumulate for millennia, if ever, the only possible movement for whitebark pine is poleward.

In summary, then: assisted migration of relatively rust-resistant forms of whitebark pine appears to provide the best chance of preserving it. The species is threatened by multiple factors, is already rare, and is in fast decline. While it may be possible to reduce the threat from WPBR, the threat from climate change remains. Experiments so far suggest that whitebark pine is currently able to survive in places that will still be hospitable to it in the second half of the 21st century (according to climate and species distribution models), but where it is not currently growing. However, it does not seem able to move itself—or, more accurately, to be moved by nutcrackers. And even if the nutcrackers *did* move whitebark pine north, given how slowly whitebark pine reaches reproductive maturity, this movement is unlikely to be able to keep up with the changing climate. So, *if* we want to preserve whitebark pine, the best chance for it is to move it ourselves.

Ethical and Value Dimensions of the Assisted Migration of Whitebark Pine

But should we move the whitebark pine? Here, we'll consider key value/ethical questions that may help us to decide whether we should, or should not, attempt to relocate the whitebark pine. We are unaware of estimates of its economic value (and it is no longer used for commercial forestry), so we will not explicitly consider such value here. Similarly, there are no estimates of the cost of assisting its migration, so we refer to these costs only in passing.

Intrinsic Value of Species

Proposals for assisted migration, including the whitebark pine, are typically motivated by the desire to preserve a species. But 'preserving species' can be a proxy for many values, including biodiversity, ecosystem function, and aesthetics – we'll consider some of these below. However, it's also often maintained that species have intrinsic (non-instrumental) value, and/or that they have moral status, and that this is a reason for protecting them.

This claim can have several forms. On one view, species *can* have (and most species *do* have) *subjective* intrinsic value, meaning that people subjectively value them (Callicott 1989, Elliot 1992). On a second view, species have *objective* intrinsic value, independently of whether anyone actually subjectively values them or not (Rolston 1986). One prominent version of this view takes objective value to mean having moral status, based on the claim that species have interests, a good of their own, and can be benefited and harmed (Johnson 2003).

Someone who accepts that a species has intrinsic value in either of these ways would normally take the view that if the species is endangered, its relocation would be permissible, and perhaps morally required, if relocation is economically and practically viable, and is likely to succeed without endangering other species or compromising other significant values. (See Hoegh-Guldberg et al. 2008 for a decision framework.) At first sight, then, unless there's evidence that moving the whitebark pine would compromise other species or values (which we'll explore later in this paper), positions that accept species' intrinsic value are very likely to be in favour of relocation. The whitebark pine seems to be highly subjectively valued (although to be certain of this, we would need to carry out an empirical study); and, if species in general have moral status, it would necessarily have moral status.

However, while there's little dispute that people do subjectively value most species, the idea that species have moral status can be challenged. It may be objected that species are not the kind of thing that can be harmed or made 'worse off', even though individual species members can be harmed or made worse off; and it's not clear what 'good for a species' means beyond good for the summed interests of its individual members (Palmer

2009). Even if we could make sense of this idea, a species is not conscious and cannot experience 'harms', so a further argument is needed as to why species' interests matter morally. Although such arguments have been made (e.g., Johnson 2003), we conclude that they are not convincing (see Sandler and Crane 2006 for a detailed discussion of these difficulties).

Sandler (2013) offers a further challenge to the idea that species carry some kind of essential, non-contextual value that a conservation strategy should endeavour to protect. First, he maintains that a species' value is tied to its ecological context and location, rather than being an ecologically detached essence that exists wherever species members do. And second, in the context of global environmental change, Sandler argues that we should, anyway, de-emphasise the preservation of single species; in the light of global environmental change, we need a much broader, system-wide ecological view, not a species-by-species approach. Protecting a species such as the whitebark pine by assisted migration is problematic, both because preserving species *ex situ* fails to protect what's actually valuable about them, and because a single-species focus is no longer an appropriate conservation strategy.

While Sandler's arguments about species' values are plausible, we have elsewhere argued that his conclusion is too limited, in part because people value species in ways - such as aesthetically - that may, after all, transfer between contexts, and because species can be valuable in new or different ways in new locations (Larson and Palmer 2013). It's possible to accept both of Sandler's strictures and still support assisted migration of a species in particular cases; in fact, as we'll go on to argue later in this paper, the whitebark pine may be such a case.

Invasiveness and Ecosystem Values

The most common objection to assisted migration is not that we lack good, value-based reasons to do it (as Sandler suggests) but that we have good, value-based reasons *not* to do it. Assisted migration means introducing a species into an area where it is not native, risking the creation of a non-native, invasive species that will flourish at the expense of

native species and/or that will disrupt the functioning of the recipient ecosystem. This concern underlies Ricciardi and Simberloff's (2008) rejection of assisted migration.

Ricciardi and Simberloff (2008) are right that the inherent uncertainties of risk assessment should make us wary of underestimating the potential risks of a newly introduced species. However, some species combine features that make them very unlikely to be invasive with the possibility of easy removal should they be invasive after all. And even Ricciardi and Simberloff (2008) concede that assisted migration is not likely to be detrimental in all situations; the difficulty lies in effectively identifying such situations. We suggest that whitebark pine is one such example; it is extremely unlikely to become invasive after being relocated because of its 'slow reproductive maturation, infrequent cone crop, poor competitive ability relative to other trees, and habitat-specialist life history strategy' (McLane and Aitken 2012: 151). After all, according to the SDMs, whitebark pine does not even occupy the range it could. In addition, if we suddenly needed to remove whitebark pine, it could be easily identified and felled. The more realistic difficulty is in getting whitebark pine to regenerate without human assistance, rather than its invasiveness in a new habitat.

Whitebark pine's lack of invasive potential means that in this way, at least, it's unlikely to threaten any ecosystems in which it is relocated. Indeed, it's worth considering possible positive ecological contributions relocation might bring. While Sandler focuses only on value in a species' original ecological context, Buma (2013: 34) maintains: 'While species may indeed lose their ecological connections via translocation and movement, they may create new ones. The loss of current context does not imply a lack of future context'. The whitebark pine might be able to forge valuable new ecological connections. If so, this would give us reasons to support assisted migration not solely based on preserving the species, but on its contributory functions in a broader ecological community.

This idea might be problematic for those who hold strong historic ecosystem values on which, perhaps based on an interpretation of 'stability' and 'integrity' *sensu* Leopold

(1949), the continued existence of a particular species-set in a particular place is what's of value. On this view, importing whitebark pine to a system outside its historic range would be problematic in principle. But where ecosystem *functions* and *interactions* are regarded as valuable, whitebark pine could make useful contributions as a new member of existing subalpine ecosystems (that will themselves already be changing in response to the shifting climate). As we've noted, whitebark pine is both a keystone and a foundation species in its current location. It is likely that it could perform this role if moved farther north, providing a valuable food source, stabilizing soils, retaining soil moisture, modifying soil temperatures, slowing the progression of snowmelt, and helping to prevent flooding at lower elevations. Given the significant changes we expect in subalpine systems as a result of climate change, the capacity of whitebark pine to act as a foundation species, providing conditions in which other species (perhaps other recent 'natural' migrants) can begin to establish themselves, could be functionally important (but would require further study). Even if the whitebark pine were not immediately to form such significant functional relationships in its new environment, its continued existence prevents the loss of an increment of biological diversity, thus retaining biodiversity options for the future.

In short, relocated whitebark pine may provide important ecosystem services into the future. Interestingly, Sandler (2013) himself argues that provision of ecosystem services should be one of the revised goals of ecological management—although he does not associate this with assisted migration. However, there's no obvious reason why, on some occasions, relocations could not perform such functions; as Sharma et al. (2013: 30) maintain, a species could be '"pulled" into an ecosystem from another location to fill a service that has declined due to climate change. While this will usually be for a direct use, such as in forestry, we should not rule out the possibility that relocated trees, such as whitebark pine, could be ecologically significant in positive ways in a new location.

Values and Sentient Animals

The close relationship of whitebark pine to a number of sentient animal species means both that moving it—and failing to move it—is likely to have implications for their

welfare. Although 'animal welfare' can be interpreted in different ways, we take 'welfare' here to refer to the subjective experience of sentient animals, where negative states such as suffering are a disvalue, and positive states such as pleasure are valuable.

The animal most obviously impacted by the fate of the whitebark pine is the Clark's Nutcracker. There is little doubt that nutcrackers are sentient, and as numerous studies—perhaps most prominently Kamil and Jones (1997)—show, they are highly intelligent corvids, with long memories for seed caches and an ability to learn geometric relations between landmarks. What might assisted migration (or continued decline to extinction) of whitebark pine mean for nutcrackers?

The current decline in whitebark pine may not cause significant suffering to existing nutcrackers, if other seed-bearing trees continue to flourish. Nonetheless, successful relocations of whitebark pine would (eventually) provide more food for nutcrackers, and support a larger nutcracker population with a more stable food supply. However, for this to happen, nutcrackers would have to be present in areas to which the whitebark pine is relocated. This raises a number of tricky issues. If whitebark pines were primarily relocated in areas contiguous with the northern boundary of existing whitebark pines, then nutcrackers would already be present (Figure 2), though as mentioned above, the density of pine plantings would need to be great enough to attract them.

Yet studies suggest that for long-term survival in the context of climate change, whitebark pine should be relocated much farther north than its current location, beyond the current range of the nutcracker (Figure 2). It's possible that nutcrackers will expand their range northward to that point on their own, but they may not. In that case, one option would be to provide 'stepping stones' of suitable whitebark pine habitat for them to gradually move northward during irruptions, but this would be an expensive option. Another option would be for the assisted migration of whitebark pine to be later accompanied by assisted migration of nutcrackers; not only for the benefit of the nutcrackers, but also to ensure future regeneration of whitebark pine without human intervention.

But the relocation of nutcrackers—as sentient animals—raises new ethical issues. In particular, relocation is likely to cause individual birds chronic stress when captured and handled, restrained, transported, and released in a new location; 'a single capture and handling incident can have lasting effects following release' (Dickens et al. 2010: 1331). We have little idea about how moves might affect social bonds between nutcrackers, but we do know that relocation of wild-caught birds to new environments causes stress; this might be particularly acute for nutcrackers, given their outstanding mapping, orientation and memory skills. In addition, the timing of nutcracker relocation is complicated. It turns out that its main alternative food sources (including Ponderosa pine, Douglas-fir and limber pine, though the former are considered less nutritious) do not occur much farther north (C. Smith, Parks Canada, personal communication), so the nutcracker relocation could not take place until the whitebark pines reached reproductive maturity, and produced seed crops sufficient to feed the nutcrackers. This means that nutcracker relocation would be delayed by thirty or more years after the relocation of the whitebark pine. This delayed relocation would have the advantage that the climate may have changed to make it closer to that in which the nutcracker is currently located; and after thirty years, it should be reasonably clear whether the whitebark pine relocation has been successful, and hence whether cone crops will be sufficient to feed nutcrackers. But nonetheless, the degree of long term planning in such a two-stage relocation adds significant logistical difficulties to the proposal.

Nutcrackers are not the only animals impacted by the current decline, and the possible assisted migration, of the whitebark pine. Many other species consume its seeds, and although no species is solely dependent on them, they are important in the diet of many Western mountain species. Studies indicate that grizzly and black bears eat the seeds (either by climbing the trees or by digging through cone middens created by red squirrels), and that Stellar's jays, ravens, pine grosbeaks, mountain chickadees and especially red squirrels also consume the seeds. While the loss of whitebark pine appears unlikely to seriously impact any of these species, their loss may have significant repercussions if it occurs at a time when food supplies are marginal. For example, Schrag et al. (2008)

predict that climate change will lead to the loss of mid-elevation, mixed-pine forests in Yellowstone National Park. These mixed forests are a better source of whitebark pine seeds for bears than high-elevation, monotypic ones because they are better habitat for red squirrel cone middens. If these mixed forests decline, the bears will be forced to descend to lower elevations, where they more often conflict with humans. Human-bear conflicts may not go well for humans, but they often go very badly for bears (Mattson et al. 1992).

While the relocation of whitebark pine will not help those animals in areas where whitebark forests are currently dying or in decline, if relocated the seeds will (eventually) provide a nutritious food source for sentient animals in more northerly parts of the mountain West. So, while it's unlikely that moving whitebark pine will cause suffering to any animals (with the exception of nutcrackers that are forcibly relocated), the whitebark pine *is* likely to provide a new nutritious food source—thus performing a useful ecosystem function.

The Value of Wildness

The mountains of the North American West, both in the US and in Canada, are widely valued for their 'wildness' or 'naturalness'. We take these important and widely held environmental values to mean being in some sense 'human independent'. As an example of their significance, in the context of geoengineering, Preston (2011: 464) argues that the protection of that which is 'human-independent' is the 'presumptive argument' of environmental ethics.

Wildness, though, can be interpreted in different ways. Hettinger and Throop (1999: 12) argue that 'something is wild in a certain respect to the extent that it is *not humanized* in that respect. An entity is humanized in the degree to which it is influenced, altered or controlled by humans'. On this interpretation, wildness seems to concern an *ongoing state* of independence from human beings. On another—perhaps more common—interpretation, the value of wildness or naturalness is understood in a *historical* way; it's about the genesis or history of an organism, species, ecosystem or place, so something is

valued as natural or wild inasmuch as it is not an artefact, and has emerged from forces and processes 'unmodified by human activity'. (Elliot 1982: 79-80)

One worry about assisted migration, then, might be that it compromises wildness (in some sense) by extending human activity into wild areas. If assisted migration of the whitebark pine threatens the value of wildness in the Western mountains, might this be a reason not to pursue it?

This question raises a number of complex issues about how the value of wildness is understood to work. To begin with, whitebark pine is severely compromised at present because of unintentional and indirect human activity: the introduction of WPBR, fire suppression, and climate change. So the threats to the species are of human origin; its wildness, or the wildness of individual trees, is (albeit indirectly and unintentionally) already compromised.

But on many views, *purposive* human activity compromises wildness even more, because humans intend, or design, particular outcomes. So, according to Preston (2011), geoengineering compromises wildness more than climate change because geoengineering designs or manipulates the climate in order to bring about specific, desired human climate goals. Similar reasoning could be applied to current purposive and goal-driven attempts to preserve the whitebark pine involving the selection and propagation of genetic strains resistant to WPBR. The very genetic fabric of the species—when selected to be rust resistant—carries a human imprint and purpose.

Translocation, though, seems to present a yet greater move from wildness: humans would not only have selected elements of the whitebark pine's genetic fabric, but also located seeds and seedlings in places where they would not have been without human intervention. And even if it's argued that relocation does not constitute a further loss of wildness than genetic selection, the whitebark pines will interact with other organisms, and might thus be thought to render the whole area in which they are located less wild. This loss of wildness would be independent of any positive contribution to ecosystem

function or ecosystem services; however functionally desirable they might be, environments that contain deliberately migrated whitebark pine reflect human designs and human intentions. As Camacho (2010) points out (in the case of assisted migration in general), this runs counter to a founding principle of U.S. conservation at least, as captured in the idea of preserving the wild character and natural condition of wilderness in the 1964 Wilderness Act.

On a 'historical' interpretation of wildness, this apparent loss of wildness may seem permanent. On an 'ongoing state' view, though, it might be argued that if humans moved whitebark pines into an area, then left the trees to forge their own relationships in the recipient system, over time the pines and the whole system might be thought to regain wildness, inasmuch as the system would be self-directing, and evolutionary processes would continue without human intervention. The potential introduction of nutcrackers at a later date, at least in the most northern areas, would mean that the 'washing back in' of wild value would be somewhat delayed; but over a longer period of time, assuming continuing human independence, this system would increasingly 'rewild'.

Given the dramatic human-introduced changes in high-elevation landscapes in the West, the question that remains here is how we should weigh the additional loss of wildness value involved in restoration and assisted migration projects. As several authors have pointed out, we need to rethink conservation in an era of climate change precisely because our impacts are now demonstratively so widespread (Minteer and Collins 2010; Sandler 2013). We no longer have an option for wild whitebark pine forest, not least because genetic strains that are resistant to WPBR appear essential to its future conservation. So the choice is either a whitebark pine forest of diminished wildness in a less wild landscape, or no whitebark pine forest at all.

Cultural, Place and Aesthetic Values

Some species are widely valued for the beauty, strangeness, charisma or symbolic significance of their members. (Rolston 1987) We value being able to experience individual organisms of those kinds, and we think the world would be a poorer place (for

us) if beings of those kinds disappeared (Russow 1981). Albrecht et al. (2013), for example, discuss (though reject) the assisted migration of polar bears to Antarctica as Arctic ice melts, on the basis of polar bears' high cultural and aesthetic value. Whitebark pine—though not quite on the scale of polar bears—also has significant aesthetic, cultural and historic value. Aesthetically, it forms distinct twisted and crooked 'krummholz communities' at the treeline (Tomback and Achuff 2010: 192). Although many people are familiar with these communities through mountain photography, fewer people actually experience such aesthetic values themselves. Nonetheless, climbers and backpackers will notice a marked change in a montane landscape as whitebark pine declines (and cannot help but notice the swathes of dead and dying whitebark pine currently dominating montane landscapes in Yellowstone National Park and elsewhere).

Could assisted migration preserve this aesthetic value? It would take decades for whitebark pine planted in new locations to aesthetically resemble the krummholtz communities now dying, although eventually they should. However, it's very unlikely that those who currently aesthetically value these treeline communities would be able to experience the new communities in their lifetime, so continuity of aesthetic value would be lost. Although, eventually, a resurgent aesthetic and cultural appreciation of new krummholtz communities *could* emerge in a new human generation, the general phenomenon of the 'shifting baseline' of people's experience of nature may suggest that those who have never experienced these communities will not miss them. Nonetheless, the extinction of the whitebark pine would close down the option entirely, denying future generations the opportunity ever to aesthetically experience such krummholtz communities for themselves.

Whitebark pines—some of which are around 1250 years old—along with other white pines (including the 5000 year old Great Basin Bristlecone Pines, the oldest living trees in the world) have high cultural and historic value for other reasons. They are centrally important to ideas of 'place' in the Western mountains; they are part of what is imagined to make the West what it is (e.g., Tomback and Achuff 2010). Logan and Powell (2001: 161-162) observe that 'Perhaps no other tree embodies the sense of the American West to

quite the same extent of a gnarled, 1,500-year-old whitebark pine clinging to life under some of the harshest conditions on the continent'. The whitebark pine has been part of the narrative of the West for hundreds of years; its loss will fundamentally change the ways in which people value Western landscapes.

Assisted migration can't help to preserve this value, because whitebark pines will no longer grow in the places where they carry such historic and cultural meaning. And planting them farther north might disrupt other existing narratives of those places, narratives that *don't* include whitebark pines. Since we don't yet know exactly where whitebark pines would be relocated, we don't know whose narrative—if anyone's—would be affected by their relocation. If the lands are home to indigenous peoples, in particular, there would need to be meaningful consultation and agreement before any relocation could happen (see Berkes et al.1991). It would be ethically problematic to add a new climate injustice of species relocation on indigenous people's lands.

These uncertainties concerning aesthetic, historic and cultural values may cause hesitation over relocating the whitebark pine. Where values are dependent on the existing local context, they will inevitably be lost; planting it elsewhere can't (as Sandler [2013] argues) retrieve context-related values, and may risk compromising context-related values elsewhere. Yet, as we'll conclude by maintaining, there are, on balance, good value-related reasons for relocating the whitebark pine.

A Concluding Argument: Why We Should Seriously Consider Assisted Migration

Assisted migration of rust-resistant strains of whitebark pine may be the only way to preserve the species into the future. If we think that a species has some kind of intrinsic value or moral status, this is a presumptive reason in favor of moving it. This reason might be defeated if the whitebark pine was likely to be invasive in its new location, and to threaten native species. But this is extremely unlikely to happen. Indeed, for 30-60 years, until relocated whitebark pine starts setting significant seeds, it will remain exactly where we planted it. Even then, it will only propagate with a healthy nutcracker population *in situ*. So, invasiveness is not a plausible reason for resisting relocation. In

addition, whitebark pines, even before they start to set seeds that may be a useful source for high altitude animals and birds, could produce ecosystem services such as retaining soil moisture, modifying soil temperatures, slowing the progression of snowmelt, and helping to moderate flooding at lower elevations. If the climate in the whitebark pine's new location were to become more like its native climate, the provision of these services might be particularly useful. In terms of ecological values, then, there is low risk and a chance of benefit from relocation.

However, our arguments also suggest that many species' values, at least in the case of the whitebark pine, *are* tied to context. Cultural, historical and place values don't transfer to a new location in this case. While wildness and aesthetic values may return as relocated whitebark pine grows and 'naturalizes', there's clearly a significant discontinuity in value. What's more, there's the possibility that aesthetic, cultural, historic and wildness values are compromised more generally in the new location (though this would depend on the particular proposal for assisted migration).

Are these value concerns sufficient to shift the balance against relocating whitebark pines? We don't think so. The situation here would be different if whitebark pine was threatened, say by WPBR, as an isolated case. But the processes at work here are at work across the globe, and certainly all the mountain regions of the American West. The landscapes into which the whitebark pine would be relocated are not going to remain as they are. The species existing there will also be moving upward and poleward. New species will move in. Novel ecosystems will form (see Hobbs et al. 2013). Narratives of place will have to change, and human influence will anyway extend across the changing landscape. The relocation of the whitebark pine would not be the intrusion of an alien into a long-established and unchanging ecosystem, but a new member of a novel ecosystem with some potentially useful functions.

In addition, though there may be discontinuity of aesthetic value, assisted migration will mean that future generations will at least have the opportunity to admire the twisted grandeur of the whitebark pines on high Northern treelines. Given the pervasiveness of

human influence, this may, also, be a time to consider deliberately creating new narratives of place: where, for instance, stories about how a species came to a place (rather than stories of wildness) become part of what *makes* the value of place. Those who argue that species have moral status might deepen these narratives in terms of 'restitution' to species, such as the whitebark pine, that have been forced out of other locations by human activities. For while it's difficult, ethically, to make an argument that restitution or reparation can be directly owed to non-humans (with the possible exception of sentient animals), it may be possible to defend the view that assisted migration of threatened species, where humans are responsible for the threat, is a kind of symbolic reparation, that perhaps expresses "a disposition to cherish what has enriched one's life, an appreciation of one's place in the universe" (Palmer 2012, Hill 1983).

To conclude: We are not arguing here for anything as strong as a *duty* to relocate the whitebark pine. However, we do consider that there are good reasons to do so, and few very strong ethical objections. Our claim is that if rust-resistant strains of whitebark pine can be clearly identified, depending on the outcome of economic and feasibility studies, and consultation at particular sites, there are likely to be places where relocation of whitebark pine is ethically desirable.

We've indicated several ways in which the whitebark pine is unusual, so generalizing from this case is difficult – and, indeed, every case will have unique features. However, in carrying out this case study, we hope at least to have suggested some useful ways of tackling assisted migration cases ethically, in terms of the relevant values that might be at stake. In particular, we have sought to be comprehensive in our taxonomy and analysis of values, partly as a model for future studies that must similarly attend to pertinent socio-ecological complexity, include both biological nuance (e.g., the association here between whitebark pine and the Clark's Nutcracker) and social importance (e.g., the cultural values of the whitebark pine). We hope that this analysis of the particular case of the whitebark pine will help to provide the basis for future (and better) studies and applications of assisted migration.

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