

LITERARY GEOGRAPHIES

Expanding Climate Science: Using Science Fiction's Worldbuilding to Imagine a Climate Changed Southwestern U.S.

Dylan M. Harris

Clark University

Abstract:

Drawing from cutting-edge climate science, popular representations of climate change convey a grim future in which life appears difficult if not impossible. While it is important to communicate the direness of future climate change, these representations depict the future as a forgone conclusion, which profoundly impacts the way climate change is perceived in the present. Rather than envisioning the future planet as a dead end, this article uses the worldbuilding inherent in science fiction to think more expansively and creatively about the possibilities of climate futures otherwise. Also drawing from cutting-edge research, science fiction builds worlds around facts, allowing readers to cognitively inhabit the future, to emotionally connect with characters that live there, and to consider the political and social implications of a climate changed planet. This paper first outlines the ways in which science fiction has already engaged with climate science. Then, this paper turns to the ways in which science fiction can work alongside climate science to better produce and communicate knowledge about climate change. By way of example, this paper will focus on a climate-changed Southwestern United States, using two novels—Claire Vaye Watkins's *Gold Fame Citrus* and Paolo Bacigalupi's *The Water Knife*—to illustrate how climate science can be augmented by the worldbuilding efforts of science fiction. Finally, this paper makes the case for expanding methods of producing and communicating knowledge about future climate change.

Keywords: science fiction; climate communication; climate change; STS; speculative political ecology; environmental humanities.

Author contact: dyharris@clarku.edu

Upward, not Northward

E. A. Abbott (1884)

Introduction

Global Warming of 1.5, the newest report from the Intergovernmental Panel on Climate Change (IPCC), one of the world's leading institutions for climate research, argues that significant changes due to the warming planet can be expected to occur much sooner than previously anticipated. Whereas the IPCC's last assessment report (AR5), compiled by more than 859 authors from 39 countries, acknowledged the risk of a world impacted by a 1.5°C increase in average global temperature, the realization of that risk was ambiguously projected into the future (IPCC 2014). Now, with this newest report, the realization of a 1.5-world is expected as early as 2040, meaning that it could potentially impact generations currently living on the planet, as opposed to solely impacting future generations (IPCC 2018). Given the weight of the report, it is no surprise that it spurred countless news and media articles. Just a few days after the report's release, the *New York Times* released its own summation (Davenport 2018), which was published only weeks after the *New York Times Magazine* published the long-form essay, *Losing Earth: The Decade We Almost Stopped Climate Change*, which details how the fight to stop climate change was lost decades ago (Rich, 2018).

The imagery used for both *NYT* articles present a bleak future, full stop. The most recent report about the 1.5-world begins with an image of a small child playing with the dehydrated bones of livestock that presumably died in Australia's severe drought from the previous year. The ground is hard and dusty, the grass brown and withered. The sky looks ominous, dark grays and blues, but with no promise of rain (Davenport 2018). The online version of *Losing Earth* begins with a slideshow of moving images. The first image shows a boat carving its way through a field of melting sea ice, followed by the words: 'Thirty years ago, we had the chance to save the planet.' The next image is of a town leveled by a natural disaster: 'The science of climate change was settled. We had a chance to act.' And finally, an image of a town subsumed by desert sands: 'Almost nothing stood in our way—except ourselves' (Rich 2018). These articles depict a desolate, climate changed future already realized. In many ways, they convey that there is no future, implying that there is no time to act, to change, to avoid these futures. While these may be the most recent iteration of these kinds of articles, there are several others. Much has been written on the utility of these kinds of articles, about the ways in which these kinds of doomsday narratives condition people's perception of climate change, as well as how they continue to shape the production of climate knowledge (Oneill and Nicholson-Cole 2009; Markowitz and Shariff 2012; Holthaus 2017). In sum, apocalypticism begets apocalypse (Jackson 2015).

Partly in response to these kinds of apocalyptic article, there is a growing number of articles – both popular and academic – that argue for scientists to be better storytellers. In his recent article for *The Guardian*, Enfield (2018) writes, 'Science can't exist without storytelling.' In a climatically precarious world, it could be dangerous to associate science with storytelling, let alone to suggest that one cannot exist without the other. However, it is worth considering Enfield's claim. Rather than suggesting that all science *is* storytelling,

Enfield argues that science depends on storytelling to better understand its own messaging while also gaining a better perspective on communicating those messages more effectively. Beyond simply acknowledging the social nature of climate knowledge production (Jasanoff 2015), a deeper consideration of the role of storytelling in both constructing and communicating climate knowledge provides insight towards imagining different kinds of climate futures, a task especially needed within the echo chamber of doomsday stories.

It should be noted that much of the apocalypticism apparent in popular media about climate change is clearly inspired by, and continues to inspire, dystopian visions of climate change found in various speculative media sources. However, whereas the *NYT* articles mentioned above convey a certainty in the fatalism of climate change, other versions of storytelling about climate change, such as those often found in science fiction, are purposely ambiguous. The worlds built in these stories, and the characters that inhabit them, allow the reader to navigate this ambiguity, making decisions for themselves rather than simply being told that the world is already doomed. This themed issue's emphasis on worldbuilding draws from various sources to provide conceptual and methodological tools not only for reconsidering the world we inhabit currently and wish to build in the future, but also for beginning the process of building those worlds. In this article, I will add to these conversations by thinking critically about the relationship between storytelling and climate science, specifically engaging with the worldbuilding practices found in contemporary science fiction, and by bringing those practices to bear on better understanding the production and communication of climate science. Whereas climate science itself can be understood as speculative, in that it is often focused on possible futures, worldbuilding brings those possible futures into focus by combining the speculative with the sociopolitical, the lived reality of climate change.

First, I will provide a brief overview of how science fiction engages with climate science. Second, I will discuss the science of future climate change through an analysis of the IPCC's Representative Concentration Pathways (RCPs), highlighting how this science is certainly 'true' while it also, in many ways, incorporates speculative elements also found in science fiction. Following from this, I will focus on the Southwestern United States as a site for understanding ongoing and future climate change by using two books – Claire Vaye Watkins's (2015) *Gold Fame Citrus* and Paolo Bacigalupi's (2015) *The Water Knife* – as examples of the ways in which science fiction worldbuilding creates an opportunity to better understand the worst-case scenarios outlined in the IPCC's RCPs. Finally, this paper will conclude by situating science fiction within the context of contemporary climate science production and communication.

Science Fiction's Worldbuilding: Traces and Portents of the Future Climate

Speculating about a future planet ravaged by climate catastrophe, Amitav Ghosh (2016: 11) asks, 'When readers and museum-goers turn to the art and literature of our time, will they not look, first and most urgently, for traces and portents of the altered world of their inheritance?' Further, 'when they fail to find them, what should they – what can they – do other than conclude that ours was a time when most forms of art and literature were drawn into the modes of concealment that prevented people from recognizing the realities of

their plight?’ With lessons, such as ‘the limitlessness of human freedom’ being valued in the stories we tell ourselves (159) – the ones that appear in all of the best-of and year-end lists – it is no surprise that climate change is often relegated to blockbuster disaster films that, much like the recent *NYT* articles mentioned above, rely heavily on apocalypticism. Stories about climate change are largely missing from popular culture, and this, Ghosh argues, dovetails with literature, stories, and art that increasingly focus on individualized experiences, barring even a cultural acquiescence towards collective action, let alone the capacity to address an issue that demands it. In the future, Ghosh argues that this time – where and how we live, and the stories we tell ourselves – will be remembered as ‘The Great Derangement’.

Aside from neglecting to mention that several ‘mainstream’ novels, like Barbara Kingsolver’s (2012) *Flight Behavior*, do deal with climate change, Ghosh (2016) does acknowledge that the literary world of science fiction has prominently featured climate change for decades. However, Ghosh seems to relegate science fiction to the corners of popular culture, arguing that science fiction’s treatment of climate change does not necessarily enter into the same cultural consciousness as other genres of fiction. In her review of Ghosh’s book, Ursula Heise (2018) favors his treatment of history and imperialism. Yet, she is critical of the way he collapses climate change and the Anthropocene into one another, and, further, questions his treatment of science fiction: ‘...it remains unclear why this neglect on the part of a certain kind of literary establishment should be a matter of intrinsic aesthetic concern. If science fiction...satisfactorily addresses the challenges of narrating the Anthropocene, why should we care whether the mainstream novel does or not?’ Indeed, climate-related science fiction, or cli-fi, has developed into its own sub-genre, with its own growing number of books that deal with climate change from multiple angles – not just catastrophe. Regarding science fiction in relation to the ‘climate crisis’ specifically, Bellamy (2018: 417-18, emphasis added by author) writes:

The climate crisis forces a cognitive transformation... The political challenge of overcoming the relentless drive of an ecologically and socially devastating fossil-fueled capitalism is just as much an imaginative project as it is a practical one. Science fictions that engage climate crisis offer more than catastrophism. *Crisis is only ever one possible outcome of the present.*

Murphy (2018: 426), writing about the relationship between climate crisis and despair, argues, “It would seem, then, that sf literature and sf studies going forward need to address and challenge the fatalism about climate change that seems rampant in today’s popular fiction.” As Ghosh notes above, the stories that society pays attention to, according to Ghosh, are often the ones that manifest socially and culturally, highlighting both the direness caused by damaged imaginations of climate change and the inability to imagine society otherwise. To this line of reasoning, Robinson (2018: 427) responds: “The need is clear, the solution is obvious: we have to invent a just and sustainable civilization which will mean inventing post-capitalism... We will blunder and fight our way to any better state. Those are good stories to tell, that’s the science fiction we need now.” It is clear, then, that science fiction texts, mainstream or not, are actively engaging with the science and politics

of climate change, making legible possible futures in which it is conceivable to consider the multiple realities of a climate changed planet.

Science fiction teaches us lessons by allowing us to envision the future in the present (Streeby 2018). It teaches us what not to do and what to avoid, and to consider what is potentially beneficial. Worldbuilding in science fiction blends the sociopolitical with the scientific, creating an aesthetic space in which the two inform one another. It should be acknowledged that science fiction has largely been dominated by mostly white, straight, male authors, which should certainly factor into any analysis of science fiction, especially given the political weight that imagining the future holds (e.g., what kinds of people are allowed to live in those futures) (see Womack 2013; Roh et al. 2015). Importantly, science fiction scholars have highlighted how worldbuilding, and its emphasis on the sociopolitical possibilities of life otherwise (e.g., not Western, white, and male), provide much needed prefigurative politics for environmental activism and justice work more broadly (Brown and Imarisha 2015; Whyte 2018). Given this important caveat regarding which kinds of worlds are typically built in science fiction, much has been written about the potential of science fiction for expanding the perspectival, imaginative, and political capacity for envisioning alternative worlds that simultaneously critique the present while also providing insight into the future (Hollinger 2003; Jameson 2005). It is not within the scope of this paper to review all of these works, but it worthwhile to note a couple.

In her most recent book, Donna J. Haraway (2016: 144-45), who has engaged with science fiction throughout much of her career (see Haraway 1991), writes a story to help narrate what she terms (borrowing from Kim Stanley Robinson (2012)) ‘The Great Dithering’. Her story, which is the last chapter in her book, details the multi-generational journey of a half-human, half-monarch butterfly species as they navigate this time period, ultimately finding ways to potentially circumvent the dithering. Whereas Haraway’s (2016) story provides lessons for thinking about the overall existential threat of climate change, Carey et al. (2016) use science fiction to engage directly in the science of climate change. Glaciology is a core component of climate science, and, like many sciences, it is significantly gendered. The authors of this article confront this reality by first outlining the historical construction of glaciological knowledge, noting how intersecting forces of colonialism, neoliberalism, and patriarchy have marginalized knowledges produced by particular groups (e.g., women and indigenous people). Then, the authors turn to other forms of knowledge to highlight ‘the diversity of representations of cryoscapes’ (Carey et al. 2016: 14). As a part of this work, the authors turn to science fiction. In particular, they turn to Ursula K. Le Guin’s (1969) book, *The Left Hand of Darkness*, which re-imagines polar explorations, among other scientific endeavors, through the lens of a gender-fluid society. This alternative vision of glaciology then feeds into the larger discourse of climate science, as the authors point out the ways in which climate science can be done differently. Both of these texts, in different ways, engage with science fiction as a way of better understanding the realities of climate change. However, science fiction also helps readers move beyond simply understanding climate change towards re-imagining and envisioning potential solutions.

In response to climate denialism, climate scientists have turned towards art as a way of better communicating the import of their work (Renssen 2017; Hawkins and Kanngieser

2017). The aim of this work is to make the impacts of climate change more visceral, and thereby more knowable. Yet, many of these arts-based interventions take place in settings (e.g., museums and art galleries) that are either geographically or culturally inaccessible to many people who are among the loudest deniers. While it is also the case that science fiction is not unanimously read among these populations either, it is worth noting that science fiction is much more accessible (Raven 2017). As mentioned above, there is a growing sub-genre or science fiction known as ‘cli-fi’, which does feature climate change more prominently. The aim of most cli-fi is not to propagandize about the truths of climate change; rather, it is to let ‘us travel to climate-changed worlds, to strive there alongside others and then to return armed with experience’ (Johns-Putra 2015). Further, if one of the largest problems in dealing with climate change is a lack of imaginative capacity to even conceive of solutions (Wapner 2016), then cli-fi allows readers to imagine future scenarios by visiting those futures, by learning with and alongside the inhabitants of those futures. Unlike other genres or mediums that deal with climate change broadly, cli-fi aims ‘to capture the anticipated changes in the biophysical system (the story told by climate science), future social system change, and the complex interactions between natural and social systems over time’ (Milkoreit 2016: 175). Rather than settling for apocalypse, cli-fi opens imaginative doors, engaging both the scientific and the sociopolitical to imagine futures otherwise and to begin imagining the suite of solutions needed to realize them.

The Multiple Dimensions of Climate Science: Expanding the RCPs through Worldbuilding

The quote that begins this article – ‘Upward, not Northward’ – comes from Edwin Abbott Abbott’s (1884) novel, *Flatland: A Romance of Many Dimensions*. The quote comes from the novel’s main character, a square living in a two-dimensional world who is struggling to understand the third dimension. He encounters a sphere, who uses the phrase ‘Upward, not Northward’ to orient the square. I mention the quote here to 1) acknowledge the limits of perception that invariably shape any knowledge production (see also Haraway 1988), especially climate science; and 2) to begin to think more expansively about the way climate science is represented and communicated, especially as it relates to the IPCC’s RCPs. Before continuing, however, it is necessary to first explain the RCPs.

The RCPs – Representative Concentration Pathways – are products of the most recent Annual Report (AR5) of the IPCC. They represent future climate scenarios based on various inputs and outputs to the climate system. These scenarios are factored into climate models to predict how the climate system will respond to these inputs and outputs in the future. In other words, the RCPs can be understood as potential storylines for the planet’s future. There are typically four storylines that are considered: RCP 2.6, RCP 4.5, RCP 6, and RCP 8.5. The future outlined by RCP 2.6 is one that is heavily mitigated by immediate climate action in the present and is often considered the ‘best case’ scenario. The future outlined by RCP 8.5 is often considered the ‘worst case’ scenario or ‘business as usual’ scenario, which is predicted to occur if no meaningful climate action is taken in the present and near future (Wayne 2013).

If the RCPs can be understood as storylines, then it is possible to say they are brought to life, or ‘read’, by climate models. According to IPCC scientists, ‘Climate models are the primary tools available for investigating the response of the climate system...’ (Flato et al. 2013). Each model is designed differently and for different ends (Demeritt 2001), but each one strives to take climate data from the past and combine it with present climate phenomena to predict the climate future. As storylines, the RCPs provide ways of interpreting climate data in the future by illustrating how certain phenomena will have different kinds of impacts across space and time. As such, climate science is speculative. I am not suggesting that this science is no less ‘true’ or that it should not be considered valid; rather, I am acknowledging that the production of climate science differs in many ways from other kinds of scientific knowledge production. I argue this difference in knowledge production helps to better situate the perspectival politics (and limits thereof) that are often overlooked in climate science production and communication. In short, it is difficult to fully understand and act upon a future that is difficult to imagine, let alone perceive in its entirety. The massive spatial and temporal scales of climate change constantly push climate scientists towards innovative ways of studying and interpreting it, which has knock on effects for the ways in which climate change is then understood, communicated, and ultimately acted upon.

There is hardly a better place to turn to better understand the production of climate science than to climate skeptics. It is commonly noted that there is a 97% consensus among climate scientists that contemporary climate change is anthropogenically driven (Oreskes 2004). There is, however, much less light shone on the science of the other 3%. Lahsen’s (2013) work analyzes the cultural politics of climate skepticism, focusing squarely on the dissidents who oppose mainstream climate science. She cites Gibbons et al.’s (1994) useful distinction between ‘Mode 1’ and ‘Mode 2’ science. Whereas ‘Mode 1’ science can be considered more discipline-based, traditional science that follows the scientific method (e.g., hypothesis, controlled experiment, etc.) as a strict code of conduct, ‘Mode 2’ science breaks from this tradition and blurs the lines of discipline-based science. Unlike ‘Mode 1’ science, which produces knowledge more or less for the sake of knowledge, ‘Mode 2’ science is often produced with particular goals in mind. With this distinction, it is possible to consider much of the production of climate science as being done by ‘Mode 2’ scientists, and that the remaining 3% can generally be considered ‘Mode 1’ scientists. Traditional meteorologists, for example, depend on older scientific methods, such as synoptic modeling, to explain how the weather functions, making predictions of weeks or months at most. Climate modelers, on the other hand, are able to use multiple scientific inputs, ranging from paleoclimate records to contemporary instrumental data, to predict the future 100 years from now, and they are often doing so with policy-relevance in mind.

This distinction is helpful for articulating how the production of mainstream climate science, while no less valid or true than more ‘traditional’ modes of scientific knowledge production, departs significantly from other kinds of science. In short, climate scientists use their tools, which are comprised of a complex system of scientifically sound checks and balances (hindcasting and forecasting), to predict the future. While prediction is certainly a part of more traditional science, the key difference is the social and political weight that accompanies the futures predicted by climate models. This work, while

invaluable, is also speculative. It is *necessarily* speculative. Whereas climate scientists are constantly keeping pace with these shifting dynamics, it is difficult to communicate these findings in a way that aligns with people's ability to understand and act upon them. Climate scientists are necessarily thinking 'upward' whereas the communication and interpretation of their results is often perceived as 'northward,' resulting in apocalyptic dead ends. It is here, at the intersection of scientific certainty and speculation, that I think science fiction's worldbuilding, with its blending of the scientific and sociopolitical, has much to offer in the way of expanding the perspectival capacity of its readers by taking them to these futures.

The worldbuilding inherent in science fiction provides an avenue for better understanding the future climates proposed by the RCPs. While science fiction is not often well known for its visualizations (with the exception of book cover art and an increasing number of graphic novels), it does allow the reader to cognitively inhabit alternative futures, to witness decisions alongside characters, and to feel the emotional weight of those decisions play out in different scenarios. In other words, science fiction allows readers to 'see' the RCPs from multiple dimensions; it can potentially add texture and depth to the RCPs, allowing them to be perceived, and ultimately better understood. If climate science can be understood as speculative, there is space then to consider the intellectual merit of science fiction's speculative nature, which is also often based on scientific research (Raven, 2017). In sum, climate science and science fiction can work closely together to better produce and communicate critical scientific knowledge. With this potential pairing in mind, the following section will look closely at two books that take their readers to an RCP 8.5, or 'worst case' scenario Southwestern United States.

A Climate Changed Southwestern United States

While this paper has so far focused mainly on the speculative nature of global climate change, it is important to note that many regions in the world are already experiencing profound climate change (Whyte 2019). Having already experienced increasing temperatures, severe droughts, climate-related insect outbreaks, and record-breaking wildfires, the Southwestern United States – California, Nevada, Utah, Colorado, Arizona, and New Mexico – is certainly among those regions already facing the worst impacts of climate change. Using the 'best case' scenario (e.g., low emission future) and 'worst case' scenario (e.g., high emission future) logic, Figure 1 illustrates that, in either scenario, temperatures are expected to increase dramatically in the region. Note that the figure discusses potential temperature change and not the global average. It is also important to note that the projected temperature increase for the 'business as usual' or 'worst case' scenario (RCP 8.5) shows an increase of 9°F (12.5°C), which is well beyond the 2°C threshold that concerns most climate scientists. In this future, the changes already taking place are expected to amplify alongside more drastic changes, such as declining or depleted water supplies, reduced and strained agricultural yields, health impacts in cities due to increased heat, flooding and erosion, and sea-level rise along the coasts (Garfin et al. 2014). It may be tempting to resign oneself to the apocalypticism that is so often associated with the future climate. However, it is necessary to fully consider and imagine these scenarios,

to think concertedly about how life would look and feel in these futures, in order to better plan for effective mitigation and adaptation strategies.

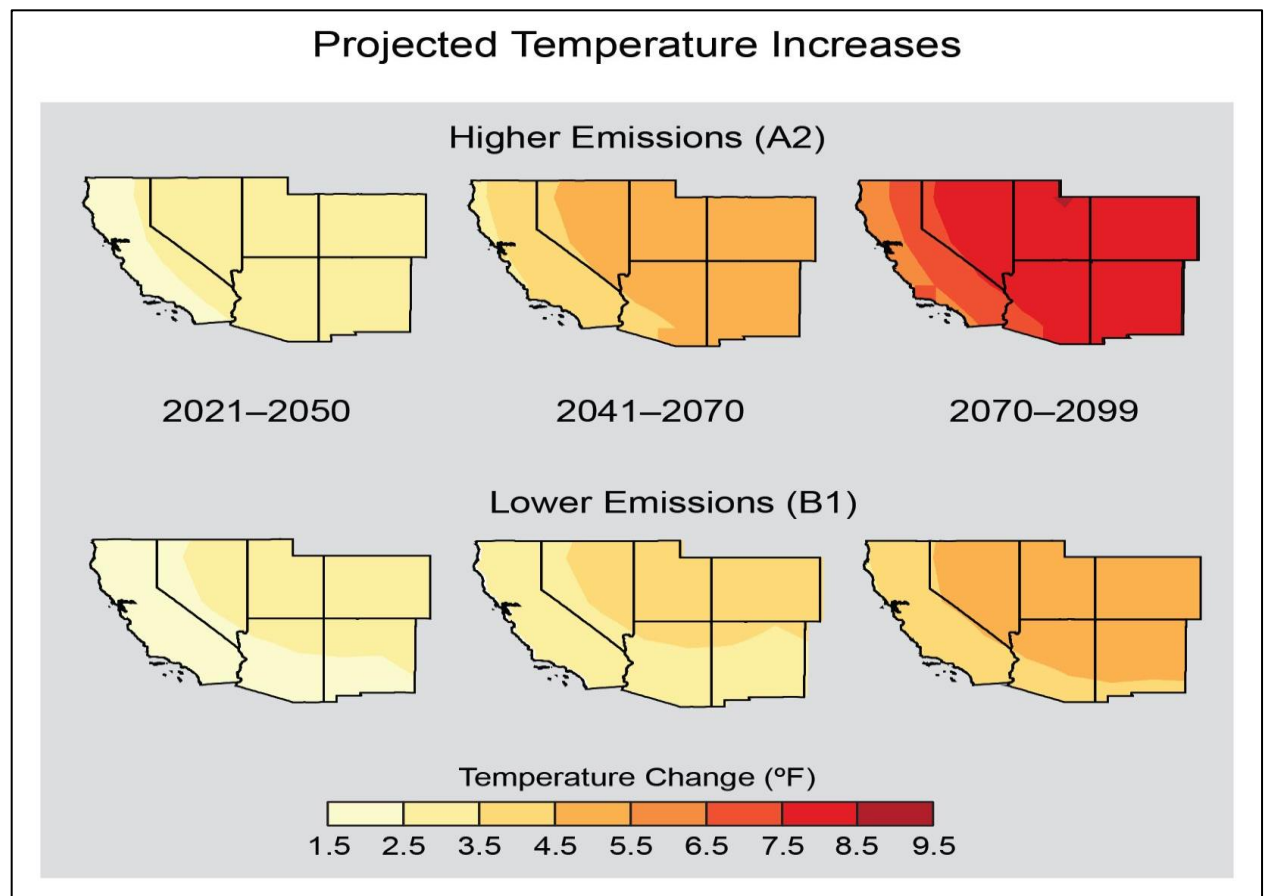


Figure 1. (Garfin et. al 2014).

Both Claire Vaye Watkins's (2015) *Gold Fame Citrus* and Paolo Bacigalupi's (2015) *The Water Knife* are set in a RCP 8.5 Southwestern United States. As with any good work of science fiction, both books are well-researched and incorporate cutting-edge science. However, rather than just presenting this research as facts, the authors build a world around it, allowing readers to feel the thirst of their characters, to feel the burn of the white hot sun on their necks, and to feel the social and political weight of future climate change in the present.

Gold Fame Citrus

The novel opens with two of its main characters – Luz Dunn, a 25-year-old former child star, and Ray, her ex-military boyfriend – squatting in an abandoned starlet's mansion in the hills outside of Los Angeles. The air is dry, and water is scarce. Sand has crept its way into their home, into their sheets. They are able to survive through a combination of scavenging, limited land-based skills, and participation in the broken-down economy where money can still be used, even if its value is precarious. As a reader, one gets the sense that

everyone who could get out already has, and the ones who are still around are there by necessity or choice. The couple decides to attend a rave in the city, where they meet and eventually kidnap (or save, depending on your reading) a toddler they name Ig. After attempting to stake out a life for their newly formed family in the abandoned starlet's home, Luz, Ray, and Ig venture east towards civilization. Along the way, their car breaks down while crossing the wasteland between LA and the Amargosa Dune Sea, a rapidly encroaching desert officially devoid of life. Ray sets off to find help, leaving Luz and Ig in the car. After nearly dying from dehydration, the two are rescued by wanderers who, drawn to the Amargosa through a psychic pull, have formed a community. The community of people 'chosen' by the Amargosa live in a DIY village at the moving edge of the desert, where they are both shielded from the gaze of civilization while also keeping a safe distance from the dunes. They survive largely from what they collect from the desert or what they can scavenge from towns that were abandoned in the wake of the Amargosa's encroachment.

Despite the presumed desolation of the Amargosa – condemned by scientists, after several efforts at recuperation, as an inevitable function of climate change – life persists. The novel, which takes on several issues associated with climate change (drought, immigration, etc.), is artfully balanced between annihilation and possibility. Though not set in Colorado, Watkins's depiction of the desert Southwest – of it being a site both condemned by scientists and celebrated by its inhabitants – dovetails with Abbott's (2012) analysis of the way Colorado is constructed in science fiction. According to Abbott, Colorado is simultaneously viewed as 'the heart of the west,' a sort of tabula rasa of wilderness ripe for readers' imaginations; a 'remnant America,' pockets of wild spaces leftover or abandoned after American conquest; and as a 'high mountain refuge,' a place where outliers can find solace. The Amargosa, which spans much of the American Southwest in Watkins's novel, is also all of these things: a tabula rasa for (re)colonization, a space where remnants of 'real' America survives, and a refuge for a community of outliers both human and non-human. For example, the founder of the wandering community has kept detailed notes of the emergent life in the desert. From jelly scorpions to walking trees, these new life forms disprove the scientific consensus that the desert is lifeless while also pointing to the stochastic and surprising ways that life continues despite, or in spite of, human intervention. In this way, Watkins allures readers to the desert while also confronting them with its danger. She intentionally creates a landscape that is sublime, which, as Csicsery-Ronay (2008: 146) writes, 'is a response to to a shock of imaginative expansion, a complex recoil and recuperation of self-consciousness coping with phenomena suddenly perceived to be too great to be comprehended'. The sublime, Csicsery-Ronay (2008) argues, is a tool in the science fiction writer's tool kit, moving readers into spaces that are both inviting and uncomfortable, the kind of emotional space, I contend, that is necessary for thinking through climate change.

With regards to climate science, the world Watkins builds in *Gold Fame Citrus* is experiencing the brunt of the changes predicted in an RCP 8.5 scenario. However, moving beyond what is typically discussed in this scenario, she draws on the science of desertification to create the uncanny world of the Amargosa. The sand dunes of the Amargosa have combined to create a super dune that moves across the desert Southwest.

All sand dunes ‘move’ through a process known as saltation in which wind moves sand grains from the dune’s surface. This eventually exposes sub-surface sand to the same process, resulting in the dunes more or less ‘moving’ by tumbling slowly forward (Herrmann 2007). In an arid region, such as a climate-changed Southwestern United States, desertification could feasibly lead to there being more sand, which could then lead to the formation of a super dune (Sauermann et al. 2001). Though the scale and movement of a desert like the Amargosa may be a bit far-fetched with regards to climate science, it reflects the harsh realities that are currently facing already-vulnerable communities in the Southwest, such as the Navajo Nation, where desertification poses a real threat (Redsteer et al. 2011). By bringing this science into her novel, then subverting it with the science fictional sublime, Watkins allows readers to experience it viscerally through the eyes of her main characters. In doing so, Watkins is shedding light on the social and political implications of catastrophic climate change, rather than simply stating the facts. Furthermore, she is bringing attention to the possibilities of lives and futures that exceed the presumed annihilation of a climate changed Southwestern United States.

The Water Knife

Bacigalupi’s novel revolves around three characters: Angel Velasquez, Lucy Monroe, and Maria Villarosa. Angel is a ‘water knife’, a mercenary sent out to cut water supplies at the whim of Catherine Case, who runs one of the major water companies in Las Vegas and, as a result, controls access to much of the scarce water in region. Lucy is a young but seasoned journalist who chose to live in the arid Southwest, motivated partly by a sense of justice and partly by inertia. Maria is a precariously employed refugee from Texas, which has been blacklisted by states further west. The plot follows these characters through the grim reality of a climate changed Southwest in which California, Nevada, and Arizona are battling to secure water rights, which are then invoked to ensure the wealthy can access water in their homes, many of which are inside climate-controlled developments called arcologies. When rumors surface of indigenous water rights to the Colorado River, Angel is sent to Phoenix, a city on the verge of collapse from a double exposure to social inequality and encroaching desertification, to secure the rights at any cost (O’Brien and Leichenko 2000). There, he encounters Lucy while she is investigating the death of a friend involved in finding the water rights. He also encounters Maria, who accepts a job that gets her involved in the hunt for the water rights.

The world of *The Water Knife* is violent, desolate, and desperate. Whereas *Gold Fame Citrus* utilized the science fictional sublime, *The Water Knife* utilizes what Csicsery-Ronay (2008: 146) considers the science fictional grotesque: ‘the realization that objects that appear familiar and under control are actually undergoing surprising transformations, conflating disparate elements not observed elsewhere in the world’. Writing further about the grotesque, Csicsery-Roney (186) notes that ‘it obstructs the mind from completing its efforts of quick understanding, arresting it when it wishes to get on with its routine of knowing, and forces it to learn something it is not sure it wants to know’. Regarding the imaginative and emotional challenges presented by climate change, this approach – of showing the readers that things are not as they seem, that they are perhaps worse – helps

shed further light on what to avoid. Though the world built in Bacigalupi's novel is grim, the reader is sympathetic to the characters. Despite their differences, their relationships are genuine. As the plot continues, readers encounter various scenarios – from gunfights to border crossings – that are made direr by the overarching reality of climate change but made more emotionally accessible because of the characters facing these challenges.

While climate science factors heavily into the world of *The Water Knife* (see Christensen et al. 2004), Bacigalupi sheds light on the politics of climate change that are often overlooked in the production of climate science. Outside of acknowledging that contemporary climate change is driven by human activity, there is rarely a discussion in mainstream climate science about *which* humans and *which* activities are the most responsible (outside of simply pointing fingers at certain nation-states). In short, the future Southwestern United States in *The Water Knife* is an extended function of uneven development (Smith 1984), which is starkly depicted by the unequal realities of the novel's rich and poor. Whereas the rich are relatively shielded from the realities of climate change in their arcologies, the poor are suffering the brunt of the changes. These divisions are mirrored in many ways in the present day when considering that marginalized and poor populations are among the most vulnerable to and impacted by climate change. The story of uneven development in the novel is told through the lens of competing legalities around water rights and access. Much has been written about the precarity of relying on water rights for dependable access to water, especially in the arid Southwest (Emel et al. 1992; Cantor 2016). Even if rights are secured, questions arise about the ability to realize these rights given the increasing water-deficiency across the Colorado River Basin (Back and Taylor 1980). While some of this water-deficiency can be attributed to climate change, much of it can be attributed to the past several decades of uneven development, specifically as a function of historical and ongoing settler colonialism, that have transformed the hydrological regime of the basin geography. While the volatility of the free market approach to resource management is largely acknowledged, it remains as one of the key strategies for securing and transferring access to different populations throughout the region (Aylward et al. 2016). As such, many of the structural social inequalities that exist in *The Water Knife's* world are not entirely far-fetched, and they must be taken into account when considering the physical reality of a RCP 8.5 Southwestern United States.

The future presented in *The Water Knife* is certainly dystopic. However, it is not hopeless. In her book, *Imagining the Future of Climate Change*, Shelley Streeby (2018) cites *The Water Knife* as a novel that uses a dystopic engine to drive the plot but also as a novel that acknowledges the historic, present, and necessary future role that Native Americans play in navigating the complexities of a climate changed Southwestern United States. In her analysis of indigenous futurisms and Native American science fiction, Streeby (58) rightfully points out:

At the same time that neoliberals were deepening imminent climate change disaster, not only was Indigenous speculative fiction challenging the Western progress narrative, but movements led by Indigenous people and people of color were already leading the way in imagining a different future.

Bacigalupi's writing confronts readers with the grim, or even grotesque, reality of future climate change, but it also allows readers the space to consider the complex politics that accompany that reality. He does this by putting indigenous water rights front and center in the narrative, asking readers to think deeply about the ways in which a climatically precarious Southwestern United States came to fruition. Within climate discourse, discussions of the RCPs may include talk of emissions, but there is rarely talk of the economic and political systems that are responsible for producing emissions. Further, the lessons to be taken away from *The Water Knife* are less about what to anticipate and more about what to make sure never happens. However, unlike apocalyptic news articles that discourage readers, Bacigalupi's novel helps educate readers by communicating the realities of a RCP 8.5 world more effectively, adding texture and depth. The issue of water rights factors squarely into the novel's plot, and it should be noted that competing water rights are a controversial facet of the present-day Southwestern United States. It is perhaps unsurprising, but no less unjust, that indigenous water rights factor precariously into contemporary water politics and the impacts of their full realization are often overlooked in large-scale studies of the region. However, efforts such as the Colorado River Basin Ten Tribes Partnership Tribal Water Study (USBR 2016), mark hopeful steps towards avoiding the climate changed future of *The Water Knife*.

Conclusions

In an interview discussing her book, *The Parable of the Sower*, another novel that deals with a climate changed Southwestern United States, Octavia E. Butler (2000: 341) is asked, 'What would you like readers to get from this novel? What would you like them to think about?', to which she responds: 'I hope people...will think about where we seem to be heading...Where are we going? What sort of future are we creating? Is it the kind of future you want to live in? If it isn't, what can we do to create a better future?' In many ways, her response to the question summarizes much of what this paper has attempted to discuss. There are many lessons to be learned from reading science fiction, especially with regards to better understanding, anticipating, and potentially curbing future climate change. However, as Manjana Mikloreit (2016) concludes from her analysis of cli-fi novels, these lessons may not be what readers want to hear. Rather than pointing towards concrete solutions, these books draw out lessons that point more to the 'the fact that climate change is not a scientific, technological, or economic problem, although it is all of these things. It is primarily a challenge to the values and ideas embedded in all parts of our lives...' (186). They take the facts from climate science, and they build worlds around them, combining the science with the sociopolitical, so readers can experience them cognitively and emotionally, providing insight into the social and political complexities that accompany future climate change.

Beginning with the apocalypticism that so often accompanies representations of climate change, this article has aimed to explain why these particular stories are not only unhelpful but are ultimately damaging. While the direness of future climate change should be discussed, it should, and can, be done in a way that allows for alternative visions of climate futures to play out and not simply present a dead end. After a brief overview of

the promise of science fiction for engaging with the prospects of future climate change, highlighting the ways in which science fiction allows its readers to live and participate in climate-changed futures, this paper turned toward the way climate science is produced and communicated. Given the prominence of the IPCC's RCPs as a scientific and political tool for predicting and planning for future climate change, it is necessary to consider 1) how they work, and 2) what kinds of knowledge they produce through their representation. In short, climate science, unlike other kinds of science, is speculative, which is not to say it is untrue. Rather, it is a future-oriented mode of scientific production that asks people to essentially consider what life may look like in a hundred years or more. With this in mind, this paper argues for the pairing of science fiction, due to its speculative but also often well-researched nature, with climate science to better understand the production of climate science while also working towards better communication of climate science's import. By way of example, this paper examined the 'worst case' scenario of a climate changed Southwestern United States through the lens of Claire Vaye Watkins's (2015) *Gold Fame Citrus* and Paolo Bacigalupi's (2015) *The Water Knife*. Both novels deal with an RCP 8.5 future differently, and both provide profound lessons for thinking through, and feeling, these futures in the present.

In the introduction to the collection, *I'm With The Bears: Short Stories from a Damaged Planet*, Bill McKibben (2011) notes that climate science explains the reality of climate change up to a point, at which it is necessary to emotionally engage in the weight of their findings through other mediums. There is no shortage of other mediums being explored to this end, from art shows, to experimental theatre, to musical collaborations; however, science fiction, because of its explicit incorporation of science and aesthetic commitment to future-oriented scenarios, is able to work alongside and augment climate science by bringing the future to the present. Science fiction worldbuilding, in particular, moves past simply imagining a climate-changed world by allowing readers to inhabit these worlds, expanding cognitive and perspectival capacities beyond understanding climate change towards envisioning and enacting futures, and solutions.

Acknowledgements

I would like to thank Gretchen L. Sneegas for several engaging me in several conversations about worldbuilding and geography and for working with Jeff Vance Martin to create this themed issue. I would also like to thank the anonymous reviewers whose feedback was helpful in shaping this paper and Sheila Hones for her editorial eye.

Works Cited

- Abbott, C. (2012) 'Rocky Mountain Refuge: Constructing "Colorado" in Science Fiction.' *Science Fiction Studies*, 39(2), pp. 221-242.
- Abbott, E. A. (1884) *Flatland: A Romance of Many Dimensions*. London, UK: Seeley & Co., Ltd.

- Aylward, B., Pilz, D., and Sanchez, L. (2016) 'The Political Economy of Markets in the Western United States.' *Part II Final Report on Political Economy of Water Markets*. AMP Insights. [Online] [Accessed 29 April 2020]. https://static1.squarespace.com/static/56d1e36d59827e6585c0b336/t/58980441c534a5fc6eb837b3/1486357591602/Water_Markets2-US_West-WEB.pdf.
- Bacigalupi, P. (2015) *The Water Knife*. New York, NY: Vintage Books.
- Back, W. D. and Taylor, J. S. (1980) 'Navajo Water Rights: Pulling the Plug on the Colorado River.' *Natural Resources Journal*, 20, pp. 71-90.
- Bellamy, B. R. (2018) 'Science Fiction and the Climate Crisis.' *Science Fiction Studies*, 45(3), pp. 417-419.
- Brown, A. M. and Imarisha, W. (2015) *Octavia's Brood: Science Fiction Stories from Social Justice Movements*. Oakland, CA: AK Press.
- Butler, O. E. (2000) *Parable of the Sower*. New York, NY: Grand Central Publishing.
- Cantor, A. (2016) 'The public trust doctrine and critical legal geographies of water in California.' *Geoforum*, 72, pp. 49-57.
- Carey, M., Jackson, M., Antonello, A. and Rushing, J. (2016) 'Glaciers, Gender, and Science: A Feminist Glaciology Framework for Global Environmental Change Research.' *Progress in Human Geography*, 40(6), pp. 770-793.
- Csicsery-Ronay, I. (2008) *The Seven Beauties of Science Fiction*. Middletown, CT: Wesleyan University Press.
- Christensen, N. S., Wood, A. W., Voisin, N. and Lettenmaier, D. P. (2004) 'The Effects of Climate Change on the Hydrology and Water Resources of the Colorado River Basin.' *Climatic Change*, 62(1-3), pp. 337-363.
- Davenport, C. (2018) 'Major Climate Report Describes a Strong Risk of Crisis as Early as 2040.' *The New York Times* 07 Oct 2018. [Online] [Accessed 19 October 2018] <https://www.nytimes.com/2018/10/07/climate/ipcc-climate-report-2040.html>.
- Demeritt, D. (2001) 'The Construction of Global Warming and the Politics of Science.' *Annals of the Association of American Geographers*, 91(2), pp. 307-337.
- Emel, J., Roberts, R. and Sauri, D. (1992) 'Ideology, property, and groundwater resources: An exploration of relations.' *Political Geography*, 11(1), pp. 37-54.
- Enfield, N. (2018) 'Our job as scientists is to find the truth. But we must also be storytellers.' *The Guardian*. 20 July 2018. [Online] [Accessed 19 October 2018] <https://www.theguardian.com/commentisfree/2018/jul/20/our-job-as-scientists-is-to-find-the-truth-but-we-must-also-be-storytellers>.
- Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S.C., Collins, C., Cox, P., Driouech, F., Emori, S., Eyring, V., Forest, C., Gleckler, P., Guilyardi, E., Jakob, C., Kattsov, V., Reason, C. and Rummukainen, M. (2013) 'Evaluation of Climate Models.' In Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. (eds) *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press, pp. 741-866.
- Garfin, G., Franco, G., Blanco, H., Comrie, A., Gonzalez, P., Piechota, T., Smyth, R. and Waskom, R. (2014) 'Southwest: Climate Change Impacts in the United States.' In

- Melillo, M., Richmond, T. and Yohe, G. W. (eds) *The Third National Climate Assessment*. U.S. Global Change Research Program, pp. 462-486.
- Ghosh, A. (2016) *The Great Derangement: Climate Change and the Unthinkable*. Chicago, IL: University of Chicago Press.
- Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. (1994) *The new production of knowledge: The dynamics of science and research in contemporary societies*. Thousand Oaks, CA: Sage.
- Haraway, D. J. (1988) 'Situated Knowledges: The science question in feminism and the privilege of partial perspective.' *Feminist Studies*, 14(3), pp. 575-599.
- Haraway, D. J. (1991) 'A Cyborg Manifesto: Science, Technology, and Socialist Feminism in the Late Twentieth Century.' In Haraway, D. (ed) *Simians, Cyborgs and Women: The Reinvention of Nature*. New York, NY: Routledge, pp. 149-181.
- Haraway, D. J. (2016) *Staying with the Trouble: Making Kin in the Chthulucene*. Durham, NC: Duke University Press.
- Hawkins, H. and Kanngieser, A. (2017) 'Artful climate change communication: overcoming abstractions, insensibilities, and distances.' *WIREs Climate Change*, 8(5), e472.
- Heise, U. K. (2018) 'Climate Stories: Review of Amitav Ghosh's "The Great Derangement."' *b2o* 19 Feb 2018. [Online] [Accessed 19 October 2018] <https://www.boundary2.org/2018/02/ursula-k-heise-climate-stories-review-of-amitav-ghoshs-the-great-derangement/>.
- Herrmann, H. J. (2007) 'Dune Formation.' In Schadschneider, A., Pöschel, T., Kühne, R., Schreckenberg, M. and Wolf, D.E. (eds) *Traffic and Granular Flow'05*. Berlin: Springer, pp. 63-77.
- Hollinger, V. (2003) 'Feminist theory and science fiction.' In James, E., Mendlesohn, F. (eds) *The Cambridge Companion to Science Fiction*. Cambridge, UK: Cambridge University Press, pp. 123-136.
- Holthaus, E. (2017) 'Stop scaring people about climate change. It doesn't work.' *Grist* 10 Jul 2017. [Online] [Accessed 19 October 2018] <https://grist.org/climate-energy/stop-scaring-people-about-climate-change-it-doesnt-work/>.
- Intergovernmental Panel on Climate Change (IPCC) (2014) *Fifth Assessment Report*. [Online] [Accessed 19 October 2018] <http://www.ipcc.ch/report/ar5/>.
- Intergovernmental Panel on Climate Change (IPCC) (2018) *Global Warming of 1.5*. [Online] [Accessed 19 October 2018] <http://www.ipcc.ch/report/sr15/>.
- Jackson, M. (2015) 'Glaciers and climate change: narratives of ruined futures.' *WIREs Climate Change*, 6, pp. 479-492.
- Jameson, F. (2005) *Archaeologies of the Future: The Desire Called Utopia and Other Science Fictions*. New York, NY: Verso.
- Jasanoff, S. (2015) Science and Technology Studies. In Bäckstrant, K. and Löwbrand, E. (eds) *Research Handbook on Climate Governance*. Cheltenham, UK: Edgar Elgar Press, pp. 36-48.
- Johns-Putra, A. (2015) "Cli-fi" novels humanise the science of climate change – and leading authors are getting in on the act.' *The Conversation* 26 Nov 2015. [Online] [Accessed

- 19 October 2018] <https://theconversation.com/cli-fi-novels-humanise-the-science-of-climate-change-and-leading-authors-are-getting-in-on-the-act-51270>.
- Kingsolver, B. (2012) *Flight Behavior*. New York, NY: Harper.
- Lahsen, M. (2013) 'Anatomy of Dissent: A Cultural Analysis of Climate Skepticism.' *American Behavioral Scientist*, 57(6), pp. 732-753.
- Le Guin, U. K. (1969) *The Left Hand of Darkness*. New York, NY: Ace Mass-Market.
- Markowitz, E. M. and Shariff, A. F. (2012) 'Climate change and moral judgment.' *Nature Climate Change*, 2, pp. 243-247.
- McKibben, B. (2011) 'Introduction.' In Martin, M. (ed) *I'm With the Bears: Short Stories from a Damaged Planet*. New York, NY: Verso, pp. 1-5.
- Milkoreit, M. (2016) 'The promise of climate fiction: imagination, storytelling, and the politics of the future.' In Wapner, P. and Elver, H. (eds) *Reimagining Climate Change*. New York, NY: Routledge, pp. 171-191.
- Murphy, P. D. (2018) SF and Anthropogenic Climate Change. *Science Fiction Studies* 45(3), pp. 425-426.
- O'Brien, K. L. and Leichenko, R. M. (2000) 'Double exposure: assessing the impacts of climate change within the context of economic globalization.' *Global Environmental Change*, 10(3), pp. 221-232.
- O'Neill, S. and Nicholson-Cole, S. (2009) "'Fear Won't Do It" Promoting Positive Engagement with Climate Change Through Visual and Iconic Representation.' *Science Communication*, 30(3), pp. 355-379.
- Oreskes, N. (2004) 'The Scientific Consensus on Climate Change.' *Science*, 306(5702), p. 1686.
- Raven, P. G. (2017) 'Telling tomorrows: Science fiction as an energy futures research tool.' *Energy Research and Social Science*, 31, pp. 164-169.
- Redsteer, M. H., Bogle, R. C. and Vogel, J. M. (2011) 'Monitoring and Analysis of Sand Dune Movement and Growth on the Navajo Nation, Southwestern United States.' *U.S. Geological Survey Fact Sheet 2011-3085*. [Online] [Accessed 19 October 2018] <https://pubs.usgs.gov/fs/2011/3085/>.
- Renssen, S. V. (2017) 'The visceral climate experience.' *Nature Climate Change*, 7, pp. 168-171.
- Rich, N. (2018) Losing Earth: The Decade We Almost Stopped Climate Change. *New York Times Magazine* 01 Aug 2018. [Online] [Accessed 19 October 2018] <https://www.nytimes.com/interactive/2018/08/01/magazine/climate-change-losing-earth.html>.
- Robinson, K. S. (2012) *2312*. New York, NY: Orbits.
- Robinson, K. S. (2018) 'Story Spaces of Climate Change.' *Science Fiction Studies*, 45(3), pp. 426-427.
- Roh, D.S., Huang, B. and Niu, G. A. (2015) *Techno-Orientalism: Imagining Asia in Speculative Fiction, History, and Media*. New Brunswick, NJ: Rutgers University Press.
- Sauermann, G., Kroy, K. and Herrmann, H. J. (2001) Continuum saltation model for sand dunes. *Physical Review E*, 64, 031305.
- Smith, N. (1984) *Uneven Development: Nature, Capital, and the Production of Space*. Athens, GA: University of Georgia Press.

- Streeby, S. (2018) *Imagining the Future of Climate Change: World-Making Through Science Fiction and Activism*. Oakland, CA: University of California Press.
- United States Bureau of Reclamation (USBR) (2016) Colorado River Basin Ten Tribes Partnership Tribal Water Study. [Online] [Accessed 19 October 2018] <https://www.usbr.gov/lc/region/programs/crbstudy/tribalwaterstudy.html>.
- Wapner, P. (2016) 'Introduction: reimagining climate change.' In Wapner, P. and Elver, H. (eds) *Reimagining Climate Change*. New York, NY: Routledge, pp. 1-13.
- Watkins, C. V. (2015) *Gold Fame Citrus*. New York, NY: Riverhead Books.
- Wayne, G. P. (2013) 'The Beginner's Guide to Representative Concentration Pathways.' *Skeptical Science*. [Online] [Accessed 19 October 2018] <https://www.skepticalscience.com/rcp.php>.
- Whyte, K. P. (2018) 'Indigenous science (fiction) for the Anthropocene: Ancestral dystopias and fantasies of climate change crises.' *Environment and Planning E: Nature and Space*, 1(1-2), pp. 224-242.
- Whyte, K. (2019) 'Too late for indigenous climate justice: Ecological and relationship tipping points.' *WIREs Climate Change*, 11(1), e603.
- Womack, Y. (2013) *Afrofuturism: The World of Black Sci-Fi and Fantasy Culture*. Chicago, IL: Lawrence Hill Books.