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The distinctive capacities of plants: re-thinking difference via invasive species

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Abstract
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Keywords
species, difference, invasive, thinking, re, plants, capacities, distinctive, via

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The distinctive capacities of plants: re-thinking difference via invasive species

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The lower status of plants relative to animals, one of the defining characteristics of Western thought, is under challenge from diverse research in botany, philosophy and the more-than-human social sciences including geography. Although the agency of plants is increasingly demonstrated, scholars have yet to fully respond, for plants, to Lulka’s call to attend more carefully to the details of nonhuman difference (Lulka D 2009 The residual humanism of hybridity: retaining a sense of the earthTransactions of the Institute of British Geographers NS 34 378–93). This paper advances the concept of the shared capacities of plants, in order to take them seriously in their own terms, and to consider what that means for human–plant relations more generally. We identify four capacities illustrated through plant lives: distinctive materialities; moving independent of humans; sensing and communicating; and taking shape as flexible bodies. Together these provide a sense of plant worlds in which distinct but highly variable plant forms have their own lives, interacting with humans and others in contingent ways. As empirical illustration we explore the adversarial relationship between rubber vine (\textit{Cryptostegia grandiflora}) and invasive plant managers in northern Australia. In this case biosecurity strategies are affected by and affecting of rubber vine, assembling plants (as individuals and collectives), feral and stock animals, fire and helicopters, human skills and legislation. Recognition of plant capacities challenges us to rethink several concepts often framed against a human norm, including agency, subjectivity and the ethics of killing.

Key words plants; biosecurity; agency; invasive; more-than-human; \textit{Cryptostegia grandiflora}

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Introduction

Plants and humans are influential co-producers of the biosphere, and their mutual futures depend on collaborations and conflicts of many kinds, not least in the significant land management issue of invasive species control (McGeoch \textit{et al.} 2010; Mooney \textit{et al.} 2005). The need for diverse scholarship on our relationships with plants has never been greater, but we are hampered by an entrenched intellectual heritage. The difference between animals and plants, and the lower status of the latter, has been one of the defining characteristics of Western thought since Aristotle defined animals as those who move and plants as those who do not (Hall 2011). That heritage is being challenged in various disciplines, and a body of botanical and philosophical research now makes the case for plants to be engaged with as subjects, rather than objects (Hall 2011; Marder 2011a 2011b 2012). Geography is an important place to extend these conversations because of its heritage of approaching human–plant relations from various perspectives. This paper conceptualises the distinctive capacities of plants with the aim of advancing understanding within more-than-human geography and extending conversations between human geography and biogeography.

Engaging with human geography, we start from Lulka’s (2009) argument that there is a residual humanism in the use of the hybridity concept when ‘nonhumans’ are lumped as a singular entity. He called for a ‘thick hybridity’ in which an adequate sense of difference is maintained. While more-than-human geographies have demonstrated the agency of plants in contexts that include trees (Jones and Cloke 2002), gardens (Hitchings 2003; Power 2005), invasion (Barker 2008; Ginn 2008), crops (Head \textit{et al.} 2012) and seeds (Phillips 2013), there has been insufficient attention in this literature to the category ‘plant’. We draw on new research involving scientific sensing to conceptualise plant capacities: the shared capacities of one grouping of beings called plants, and the differences they bring to relations with humans and others. We understand plant capacities as relational achievements, the relations in question enacted with the sun, water and soil, and also often with humans and other animals. These are contingent relationships in which categories and forms should not be reified, even though they may congeal and be stabilised for very long periods of time.
From biogeography and ecology, we draw particular attention to recent concepts of anthropogenic biomes (or anthromes) (Ellis and Ramankutty 2008) and novel ecosystems (Hobbs et al. 2006 2013a) that, in contrast to mainstream biogeographic approaches, have explicitly brought the human into the system under consideration. The profound transformations and future uncertainties in the landscapes of the Anthropocene require such consideration (Lorimer 2012; Robbins and Moore 2013), but much of the relevant action is happening at much more local scales than, for example, seen in anthromes.

The issue of invasive plant management is a signature challenge of the Anthropocene, and one to which both human geography and biogeography are making important contributions (Warren 2007; Webber and Scott 2012). In this paper we develop a particular case of rubber vine (Cryptostegia grandiflora), managed as an invasive species in northern Australia. Presenting a new empirical study on rubber vine management, we show how the distinctive capacities of plants are expressed in particular ways in rubber vine and its relations with humans, animals and a host of others. Our ethnographic focus on the practice of an adversarial relationship provides new perspectives on such relations. As Lorimer has argued, most work in more-than-human geographies has tended towards affirmative relations and has yet to focus on examples in which the interested parties—human and nonhuman—are engaged in lethal and antagonistic relations. (2012, 604–5)

Ginn (2013) has recently used the concept of detachment in considering gardener–slug relationships in British gardens. As with slugs, many human interactions with plants involve the death of the latter, thus invoking questions of ethics and responsibility, whether towards individuals, species or landscapes. The policy rhetoric of invasive plant management is very much about human control; however, the experience is often rather different on the ground, where no practitioner doubts the agency of plants.

We understand questions of ontology and biopolitics as ‘a deeply empirical affair’ (Hinchliffe and Bingham 2008, 1541), emergent from contingent relations. As such, we explore one attempt to manage, or live with/out, plants: rubber vine biosecurity in northern Australia. Questions of how our conceptualisation of plant capacities might manifest in other spaces and times remains critical, but open. The case included in this paper demonstrates how the capacities of plants, enacted by rubber vine in relation with others (including humans, animals, helicopter, fire and legislation), challenge us to rethink how agency and subjectivity are conceptualised.

Plant subjects in human geography

Human geographers and others have contested the idea and practice of human exceptionalism, and used this to rethink human and nonhuman identity and subjectivity (Anderson 1995 2007; Emel et al. 2002; Haraway 2008; Plumwood 1993; Whatmore 1997). Feminist thought has been an important part of this challenge to the constitution of the autonomous, rational Cartesian subject (Plumwood 1993). If the human cannot be privileged in ways long assumed, there are many challenging discussions to be had around how we develop more ethical relationships with animals (Whatmore and Thorne 1998), bacteria (Hird 2010) and the indifferent earth itself (Clark 2011). A somewhat parallel conversation has been happening in anthropology. Notwithstanding its rich heritage of ethnographic study of the ways human societies engage with and conceptualise plants (Geissler and Prince 2009; Mosko 2009; Nazarea 2006), multispecies ethnography (Kirksey and Helmreich 2010) now attempts to recognise the plants themselves, along with other nonhumans, as key players.

Recognising the value of such an approach with plants, Jones and Cloke argue that there is ‘considerable scope for widening discussions of non-human agency to embrace beings or entities which are more markedly different than animals from the human’ (2002, 8). They examined trees to provide a ‘detailed and grounded account of the non-human agency of particular beings, things and materials’ (2002, 48). In doing so, they cautioned that a purely relational formulation of agency risks losing the analytic possibilities of understanding differences within networks, in the abilities and agencies of particular beings/things. For Jones and Cloke, this meant the possible loss of the tree-ness of trees, and therefore their specific agentic possibilities;

the failure to articulate non-human agency within its own ecological time-scales as well as in its own places has made it difficult to grasp the notion of non-human agency within extant and more anthropocentric views of agency. (2008, 82)

There are connections here to Hird’s (2010, 37) argument that since bacteria sustain life on earth through their production of key chemicals (oxygen, nitrogen, phosphorous, sulphur, carbon), and that because ‘symbioses are obligate for animals but not bacteria’, ‘these species-defying organisms do precede relating’. In Hird’s case, relationality seems to include only relations with humans; however, it is presumably possible to conceptualise bacteria – or other nonhumans – as relational achievements without humans necessarily being involved.

A number of geographers have recently analysed vernacular human experiences of the agency of plants.

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(Cloke and Jones 2001; Hitchings 2003; Hitchings and Jones 2004; Power 2005). Such experiences are characterised by people in both positive and negative terms. Plants display individual liveliness and beauty (Hitchings 2003), exert calming influences (Hitchings 2006) and draw (and are drawn into) patterns of care with people (Power 2005). On the other hand, plants have lives of their own beyond human control, which can lead to uneasiness and ‘awkward encounters’ when ‘plants are perhaps no longer often thought about in terms of their capacities and behaviours’ (Hitchings 2007a, 372). For Ginn (2008) animals and plants are both active participants and subversive agents in the colonial landscape of Aotearoa New Zealand, the context in which Barker discusses contemporary agency and changeability of gorse and its management. Barker argues that ‘gorse itself has interjected’ (2008, 1609) in the way conceptual boundaries are constructed, for example by acting as a nursery crop for native species. It may be that Australasian practice has been somewhat ahead of social theory in its pragmatic engagement with exuberant life (Clark 2013), yet as our empirical case shows, much Australian legislation and policy are distinctly less comfortable with such exuberance.

Like Jones and Cloke (2008), Lulka was keen to ask whether a purely relational hybridity had gone too far: ‘There has been, it seems, considerable equivocation about the place of nonhuman corporeality in geographical writings that has yet to be fully resolved’ (2009, 381). He argued that ‘there is currently no depth to the term ‘nonhuman’. And because there is no depth to the term, there is no way of conceiving that nonhumans may act in hybrid ways, largely out of reach of society, that have nothing to do with humans’ (2009, 383). Adding depth to how we conceive of plants and their relations, in his close engagement with forest ethnography, Staddon found that

At virtually every turn ... forest resources are not just objects of human intention and action but also subjects in a much more fully dynamic and fascinating relationship - and indeed ... the very language of subjects and objects began to break down. (2009, 72)

It is notable that these independent nonhuman lives are always easier to imagine with animals than plants (see for example Risan (2005) on the subjectivity of cows). Engaging deeply with beings such as plants is easier said than done. Most of us profoundly background plants. There are distinct methodological challenges in accessing some of the more subtle aspects of plant agency (Hitchings and Jones 2004). However, contradicting this approach, it is not difficult to accept that plants move, assess, evoke, grow, adjust, spread, use, limit and resist as they enact their own worlds, and ones shared with we humans (Latour 2005, 72). By conceptualising the capacities of plants as we do, we hope to highlight some of these possibilities and stimulate further conversations about how to consider plants more fully. Following Haraway’s (2011) advice of ‘staying with the trouble’, we need to spend more time with plants – differentiating the nonhuman and deepening our studies of them.

The human in biogeography

If human geographies have been rather slow to specifically consider plants, within biogeography there has until recently been a converse gap on the question of humans. Although biogeography would in theory claim a holistic remit that includes humans as part of earth’s biota, its usual practice has reinforced humans as different from and separate to the rest of nature. Most biogeographers now recognise that the vegetation patterns they are studying reflect both deep time evolutionary pathways and the ‘muddy and indecipherable blur’ of human influence (Mackey 2008, 392), but ‘an outdated view of the world as “natural ecosystems with humans disturbing them”... remains the mainstream view’ (Ellis and Ramankutty 2008, 445). Palaeoecological evidence of long-term human impacts was among the first to challenge that view (Kershaw 1986; Willis et al. 2007; for other exceptions see Atchison 2009; Ladle and Jepson 2008; Laris 2011; Pickett et al. 2011).

Two influential bodies of recent work have reconfigured biogeography and ecology to systematically include humans, and are particularly relevant to the discussion of invasive plants. Ellis and Ramankutty (2008) revised global biomes – a key analytical unit of conventional biogeography – to explicitly include human agency in vegetation systems. They characterised 18 ‘anthropogenic biomes’ (2008, 440) (later ‘anthromes’), based on empirical analysis of population, land use and land cover at a spatial resolution of ~86 km². Examples included ‘rice villages’, ‘residential irrigated cropland’ and ‘populated forests’ (Ellis and Ramankutty 2008, figure 1). This is the first systematic attempt to render visible the extent to which human presence and processes have become embedded in the structure of biomes. It has been driven by the bottom up empirical evidence of a transformed earth, albeit as the authors acknowledge, there is still much to find in the human–plant relationship below their smallest pixel size. Indeed anthromes are understood as mosaic formations that contain considerable variability (Ellis 2013). Anthropogenic loss of native species and anthropogenic introductions interact to increase species richness in many regional landscapes, even while global biodiversity is thinning (Ellis et al. 2012).

The second, related body of work advances the concept of the novel ecosystem:

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a system of abiotic, biotic and social components (and their interactions) that, by virtue of human influence, differ from those that prevailed historically, having a tendency to self-organize and manifest novel qualities without intensive human management. (Hobbs et al. 2013b, 58)

Here the presence and influence of people is recognised, but within a framework characterised by uncertainty and surprise, that humans do not control. That such a perspective is still considered controversial in mainstream biogeography and ecology can be seen in the vociferous debates over applying these perspectives to questions of invasive plant management (Davis et al. 2011; Simberloff 2011). Our empirical focus in this paper on practices of engagement between plants, people and others, at very fine-grained scales, draws both these bodies of literature into conversation.

The lively capacities of plants

In this section we draw mainly on recent biological research to conceptualise what we call the capacities of plants. Given the diverse ways in which the concept of relationality is understood in the literature, we emphasise three ways in which we see such capacities as relational. First, we do not assume humans have to be part of the relations, although they often are. Second, relationality can be intra-organism, referring to the processes constituting that organism. It is not only about external relations. Third, relationality is not a synonym for dynamism and fluidity. It can congeal and solidify in forms and processes that persist over long periods of time – in the case of plants, extremely long periods of evolutionary time.

Figure 1 The Western Australian (WA), Northern Territory (NT) border zone. Management focus is on rubber vine outbreaks in the headwaters of Lake Argyle. Source: Prepared by Peter Johnson based on 1:100 000 topographic maps.
Particular plant species or individuals may have additional capacities – such as rubber vine’s facility to burn or to manifest in varied form – but this conceptualisation offers a sense of what plants can do, providing a basis for further exploration. These are shared capacities that constitute their liveliness and difference from other beings, and provide the basis from which we go on to understand their agency and subjectivity.

**Distinctive materialities**

Plants are considered by scientists to (usually) share a set of five capacities or practices that distinguish them from other beings. First, performing photosynthesis, plants enacting their capacity to ‘eat the sun’ (Morton 2009), is the most profound difference between plants and animals. All living organisms require carbon in one form or another for essential life processes like growth and metabolism, and since photosynthesis is the only way to convert carbon from inorganic (non-available) to organic (available) forms, life depends on this process that – most of the time – is done by plants.1 In carrying out photosynthesis, plants trophically underpin terrestrial, aquatic and marine ecosystems. They also maintain stable oxygenation of the atmosphere and water availability. Over geological timescales, plants drive the carbon cycles of the planet.

Photosynthesis also produces complex sugars and other compounds, allowing plants to store starch and form cellulose cell walls – abilities dependent on multicellular generation. Starch provides energy for growth while cellulose becomes fibrous, giving structure and strength to plants. Finally, plants alternate generations in their lifecycles – or perform sporic meiosis – during reproduction.2 In taxonomy, this set of five capacities – clearly tied to material forms and relations – differentiate plants from other beings.

These capacities came together in evolutionary time long before humans, and consequent plant materialities have implications for human–plant relations. Plants’ capacity to photosynthesise affords humans the opportunity to live and breathe, eat and thrive. Plants have affected the ways our bodies evolved, and continue to be fundamental to our daily bodily relations. Morton (2009) argues that we are not so much embedded in the earth as in the relationship between the earth and the sun, a notion worthy of consideration in efforts to decentre humans in human–plant studies. These materialities also pervade and help shape the capacities in the following sections.

**Moving without humans**

As mentioned, Aristotle defined animals as those who move and plants as those who do not. Immobility continues to be a widely accepted defining criterion for plants, including in geography (see Lorimer 2010, 493; Lulka 2009, 386). However, Hall (2011) has shown many faults with this logic, founded mostly on failures to observe actual plants, for instance contrasting Aristotle’s practices with those of his pupil Theophrastus. In geographic discussions of plant mobility, agency is usually attributed to people, for example in discussions of portmanteau biota and colonial plant movements (Crosby 1986) and in the definition of native species (Chew and Hamilton 2011). Our point is not to ignore the significance of human movements of plants, but rather to also consider the mobility of plants that is independent of humans (albeit relational with such things as wind, internal water pressure and angles of the sun).

To see plants as immobile is to have a very partial view of what constitutes mobility. Compensating for the limits of sessile living, some parts of plants move. For example, mobility during the reproductive phase relates with the capacity of plants to alternate generations during their lifecycles. Protective sporopollenin enables the spores and pollen of terrestrial plants to widely disperse away from the rooted parent organism, allowing future generations to overcome potentially restrictive or difficult local conditions (Kinlan and Gaines 2003). Although the movements of plant parts (fruit, pollen, seeds) are widely considered to be at the ‘mercy’ of other agents of dispersal (animals, wind, water), plants capitalise on the movements of others to their own advantage (Clark 2000). Plants use animal mobilities for purposes of reproduction and more. When lima bean plants are attacked by herbivorous spider mites, for instance, they excrete a substance that attracts predatory spider mites, which then eat the herbivores (Huey et al. 2002, 417). In this move, lima bean plants act, with and against spider mites, to stop their own destruction.

Even as they are rooted in place, plants move. Since Charles and Francis Darwin (1881) postulated that plant movements might be due to turgescence (osmotic pressure relationships as plant cells respond to environmental stimulus), changing technologies have allowed scientific knowledge of plant mobilities to become more detailed. Edwards and Moles (2009) define three categories of plant movement: circumnutation, tropic responses and nastic responses. Circumnutation describes the corkscrew-like radial twining motion of the growing tips of plants, which all plants do (though at different rates and for various lifespans). The questing and grasping movements of pea tendrils, for example, are well known and easily observed. Response movements, whether tropic or nastic, can be rapid or gradual, rhythmic or irregular. In tropic responses, sensing plants move toward potentially beneficial and away from potentially problematic encounters with light, gravity, structures or water. The mimosa plant, which quickly collapses its leaves from
where it is disturbed, is known for this kind of response. In contrast, nastic responses occur when plants react in a non-directional way. Examples of this kind of plant mobility include the folding in of leaves at night as part of ‘sleep movements’ (Kiss 2006) or the rhythmic opening and closing of guard cells around stomatal pores in leaves.

**Sensing and communicating**

The facilitation of the above kinds of movement depends on plants sensing and communicating. Internally, plants communicate through assemblages of proteins, minerals and chemicals, carrying complex signals to various cells and tissues (Trewavas 2002). Over time and through such processes, learning and memory may develop (Trewavas 2005). The Venus fly trap, for example, can be said to have sensory memory similar to animals in its ability to detect, react to and trap its prey. The rapid closing of leaves (or trap) occurs when at least two sensor hairs respond to stimulus and chemicals are released, signalling specified leaves to close (Ueda et al. 2007 2010). Debates about chemical signalling challenge our ideas about passivity, by suggesting that plants perceive, process and react to environmental information.

In part, plant responses are considered passive rather than active because human lifetimes provide the referential framework (Edwards and Moles 2009). At human timescales, the multiple dimensions of plant agency are obscured, ‘both more intimate and more abstract than with any animal’ (Morton 2009, 231). If, however, plants are considered within their own lifetimes and scales, their responses become active (in sometimes quite sophisticated ways) rather than passive.

Trewavas (2002 2005) has argued specifically for plant intelligence to be recognised, referencing plants’ many reproductive, adaptive, communicative, planning and predictive capacities (see Firn 2004 for a contrary argument). This debate is significant for showing how botanists are currently thinking about plant lives and provides productive connection to social science efforts to recognise nature’s ‘active voice’ (see Plumwood 2009). The concept of intelligence has such a strong connection to human-centred concepts of mind and consciousness that it is hard to attribute it to other beings without resorting to a human yardstick. We note two ways in which plants may stimulate further thought in this area. First, intelligence is arguably an essential characteristic rather than a relational one. In our relational analysis of capacities we are trying to attend to what plants do rather than what they are (e.g. intelligent or not). Second, the disagreement between Trewavas and Firn is partly over whether plants are individuals, with Firn arguing that plants cannot be intelligent because they are not individuals. Animals again provide the reference for what it means to be an individual. Plants, however, challenge this sense of individuality, as we now discuss.

**Flexible bodies**

The fact that plants take many different, fascinating and sometimes seemingly bizarre forms is a staple of natural history books and documentaries. Here we are concerned not so much with differences of form, but with what this allows us to infer about the plant self or individual. The way in which understanding of the body is bound up in understanding the self has been extensively discussed in feminist analyses, and a number of authors have extended this thinking to other-than-human bodies (Atchison and Head 2013; Hitchings 2003; Marder 2012; Rayner 1997).

Plants confront understandings of the body that use the human or even animal body as reference point. Plant identity stretches across what Rayner (1997) calls ‘dynamic boundaries’. These boundaries include those between self and non-self, fixture and indeterminacy, and individual and collective form. Growth in animals constitutes the enlargement of juveniles, leading to a relatively clear delineation of the bodily self. For plants, however, growth involves reconfiguration of cell ‘con federations’ (Firn 2004). These dynamic boundaries of plants often lead to uncertainty in human engagements with plants, for example discomfort in a London garden (Hitchings 2007b) or indecision in invasive species eradication (Atchison and Head 2013).

To summarise then, our argument is not only that plants have agency (a point well made by others) and subjectivity (a more controversial proposition) but also that focusing on plant worlds shows how human-centred our conceptualisations of agency and subjectivity have been. Thinking more broadly about alternative modes of mobility, communication and the individual self, as expressed in plants, challenges us to open up those larger concepts. These movements, senses and flexibilities come together to give a general sense of what it means to live as a plant, but though these are (mostly) shared by plants, each species, even each plant, has its own dynamic manifestations of form and relations – with humans and otherwise. Engaging with different categories of plant (trees, wheat, seeds, food) gives researchers different insights. In the following case, our focus falls on rubber vine.

**Living with/out rubber vine in northern Australia**

We focus on the being/s named by scientific taxonomy as Cryptostegia grandiflora ( Roxb) R. Brown (rubber vine), a woody perennial in the Apocynaceae. In biogeographic terms rubber vine is endemic to Madagascar; however, its current distribution is attributed to

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human agency, particularly as part of colonial experiments in rubber plantations (Brockway 1979; Meve and Liede 2002). Like other milkweeds of the Apocynaceae and Asclepiadaceae families (Farrell 2001), rubber vine produces latex, an aqueous alkaloid suspension made in living plant cells. More than 20 000 species of (mostly) tropical plants create latex, which acts to ‘chemically mediate ecological interactions’ (Lewinsohn 1991, 64). Providing a coordinated defence mechanism, rubber vine’s latex – and its secondary metabolite, rubber – work to reduce herbivory, entrap insects in stickiness, and seal wounds preventing infection (Agrawal and Konno 2009). Colonial efforts to turn rubber vine’s latex to human purposes for rubber production proved commercially unviable. After experimental sites were abandoned, rubber vine naturalised, spreading across extensive areas including Haiti and southern Florida (Findlay 2009). Several factors contribute to rubber vine’s successful spreading. First, it adapts reproduction to conditions. Rubber vine flowers opportunistically with rainfall, producing more pods per vine and more flowering events in wetter years (Grice 1996). Second, it is prolific, producing large seed pods with up to 8000 seeds per mature plant per reproductive event (Grice 1996). And third, it uses multiple dispersal methods – floating pods disperse widely in collaboration with flows of water or wind.

In Australia, rubber vine has been recorded since 1875, probably introduced as a garden ornamental into mining camps in Queensland. It quickly became established in areas such as the river systems of the Gulf of Carpentaria (Palmer and Vogler 2012). It grows on a wide variety of soil types including saline soils and across savannah, riparian and coastal habitats with rainfall between 400 and 1400 mm a year (Palmer and Vogler 2012). In northern Australia rubber vine has two growth habits: it grows as free-standing but also interconnected bushes (or shrubs) where water is scarce; and along riparian corridors it forms towers of vine from ‘prehensile’-like whips (ARMCANZ 2001), climbing and smothering other plants as its vines intertwine to create thick mats spreading across kilometres of canopy.

Australian biosecurity strategies target rubber vine as a ‘weed of national significance’ (WoNS). With its dense growth habit, it is considered a threat to biodiversity in woodland and subtropical rainforest environments, including Ramsar wetlands and World Heritage Areas in Queensland (ARMCANZ 2001). Rubber vine also poses significant costs and risks to the pastoral (increasing the cost of mustering and reducing pastoral productivity) and tourism industries, perhaps the real reason for the resources it attracts under invasive species governance programmes. Under the WoNS programme (NRMMC 2007), a national priority action framework for each species (including rubber vine) directs funding and guides planning across jurisdictions, for example in the designation of eradication, containment and control zones (see Figures 1 and 2). The nature of Australian federalism, in which natural resource management is a state rather than federal responsibility, increases the complexity of the governance challenge and leads to multiple state classifications and regulatory frameworks for rubber vine and other invasives.

We are not necessarily arguing that rubber vine-invaded landscapes constitute novel ecosystems as defined by Hobbs et al. (2006). There are many tensions inherent in the concept of novel ecosystems (Marris et al. 2013), including debate around the issue of invasives’ inclusion. Richardson and Gaertner (2013) argue that invasive plants and novel ecosystems have been too loosely conflated, the former not necessarily producing the threshold changes necessary for the latter. Nevertheless, many widely discussed examples of novel ecosystems contain invasive plants, and there is a live discussion in northern Australian savanna biogeography about whether invasives such as Gamba grass (Andropogon gayanus) are on the verge of triggering a shift to fundamentally transformed ecosystems through their influence on fire regimes (Setterfield et al. 2010). We do argue, however, that rubber vine and other invasives must now be understood – both conceptually and in practice – as part of the ecology of northern Australia.

Rubber vine now covers an estimated 700 000 ha across Australia’s tropical north and manifests within 35 million hectares, or 20 per cent, of Queensland (ARMCANZ 2001); however, the scale of its distribution means that it does not show up in either biome or anthrome analyses. This region of northern Australia is part of the ‘tropical grassland, savanna and shrubland’ biome and the ‘remote rangelands’ anthrome (Ellis et al. 2013, Appendix S3). Invasive species are mapped as comprising a relatively small (less than 2.5) percentage of native species (Ellis 2013, figure 1J). Clearly the scale of such analysis needs to be complemented by more fine-grained analyses of how the people and the plants interact on the ground, particularly for a plant like rubber vine, which is considered highly problematic.

In the following sections we report results from ethnographic fieldwork with invasive species managers in northern Australia in the dry seasons of 2011 and 2012, extending from eradication sites in northern Western Australia (Figure 1), across the Northern Territory to containment zones in North Queensland (Figure 2). Interviews were undertaken in Kununurra, Darwin, Mackay and near Georgetown in the Gulf of Carpentaria, with government weed officers, scientists, indigenous rangers, local and state community environment groups, and two pastoral station managers.
Both men and women were well represented. Participant observation of surveillance, monitoring, eradication and control processes was also undertaken at several sites. The three following sub-sections reflect themes that emerged from our analyses of field observations and interviews. The capacities we have outlined above as shared among plants are threaded through these relations of biosecurity, displaying shifting levels of influence as well as combining with additional capacities of rubber vine.

Figure 2  Rubber vine management zones within Queensland showing the outlier or outbreak targets, the containment line and infestation areas

Appearance, seeing and sensing

Whereas rubber vine senses its surroundings to move into and around suitable habitats, so managers need to see and sense these movements. Paul has been a federal weed officer for the past 20 years, focusing on rubber vine eradication at the edge of outlying occurrences within Queensland (Figure 2). Part of his job has been to help state weed officers coordinate their efforts across different jurisdictions. He has also played a significant role in communicating knowledge about rubber vine management to landholder groups. As Paul explains, a rubber vine seed takes about 18 months to germinate and grow to reproductive age, when it can flower and set seed again. On the very large properties of the area, this short window of time provides little opportunity for pastoralists to take notice, let alone mobilise resources to manage rubber vine. As Paul puts it, ‘they can’t see it at the moment’. The combination of relatively quick reproductive capacity and remote location makes it difficult for Paul to undertake an effective weed awareness programme. In most cases, once landholders or managers detect plants rubber vine has exceeded the ‘outbreak’ or outlier category. It ‘suddenly creeps up on you’, and then can only be managed under more pragmatic ‘control’ programmes.

Conversely, climbing vine entanglement takes place over a longer timescale. Daryl, previously a district agronomist in Victoria, made his ‘tree change’ to the Queensland Gulf with his family over 30 years ago. Daryl’s description illustrates the slow process of rubber vine growing in, and then over, standing trees and other vegetation. This process is so insidious that it took his ‘fresh’ eyes to really notice.

In the riparian zones at 2 metres [high] there’s a tree it [rubber vine] can climb . . . It might take 10 to 15 years to get up there and it’s just slowly climbing and not doing much, and then eventually it gets to the top, because it loves sunlight, needs sunlight, and it might be two or three little vines that have done this over that time . . . Now once they get up there and they’ve got their castle to sit on, then they just explode and the weight of the rubber vine plant starts to break the little branches out of the tree, the top of the tree, then it takes out the bigger branches and then it starts to seriously damage the crown of the tree and that’s usually, I say it’s around the 40 year mark, from experience . . . There’s nothing clever about it, it’s just the fresh eyes I think, and I would see changes occurring and the people that lived there would go, ‘oh yeah, maybe it’s changed a bit’. And I’m thinking, no, when we came up here in ’82 I know that that river system was clean, you know, there was no fringing vegetation. And 10 years later it’s gone 2 or 300 yards out into the open land. (Daryl, weed manager, land owner, Queensland)

In the north of Western Australia, weed officers have been (so far successfully) eradicating small outbreaks of rubber vine for more than 15 years. The latest detection was made by pastoral station manager Bob, who noticed the purple flowers and arching whips of a lone plant just 200 metres from the homestead yards. Bob’s vigilance for rubber vine was honed during previous work in Queensland. His keen eyes and a few phone calls quickly mobilised weed officer Trudy, as well as Paul from Queensland and the multi-agency team of weed management staff and rangers. During our go-along interview Bob plunged into chest-high grass to show us the single plant. In fact, the vine he was to show us had been dead (after treatment) for over a month. It was shrivelled and barely discernible from the shrub it had been growing over, except to Bob, who pointed out its distinctive spotted purplish stem.

Humans need a particular kind of mobility to do their sensing of rubber vine well. Although 4WD vehicles, quad bikes and boats are all used in weed management, in some areas helicopters are the only means of gaining access. In particularly remote areas, provisions for a number of days or weeks are flown to a surveillance base location. Although there are particular risks and higher costs with helicopter biosecurity, the areas that can be covered by a small group make it a cost-effective option. Moreover particular weeds – including rubber vine – are more easily seen from above (from a low flying helicopter) than from below (in a vehicle). It is from the air that the characteristic towers of rubber vine are most easily seen as showy displays of purple flowers and/or shiny new leaves against duller background vegetation. However, this is not a straightforward task: younger plants may not flower heavily for the first two to three years, and so may not be visible until they have matured and already set seed; very large areas may need to be assessed if infestations are sparsely distributed; and it takes an experienced set of eyes to know what to look for.

Spotting rubber vine from helicopters is a learned skill that takes practice in different light conditions. Paul described this process:

you get a feel for things and at certain times, [if] the sun was coming from behind you shining on through that canopy, you’d be able to pick out, well, you’d be able to go and say, ‘hang on, yeah, shiny leaf, yeah, it looks characteristic, let’s go, yeah, let’s come over this site.’

Interviewer: So there’s nothing else that might be confused with it?

Oh, there’s quite a few other native species that you can get very confused with but the distinct characteristics, I guess this is what we sort of picked up, was about timing in terms of the seasonal conditions. You’d time your surveys to suit the conditions on site. For instance if they had rain now, . . . you might do a survey in . . . 6 weeks or 8 weeks time and then obviously the leaf arrangement and that leaf display, just being a plain green leaf and quite glossy, and how it sits on that canopy as well. (Paul, weed officer, Queensland)
Digital devices operated in the air by the weed spotters allow for detected plants to be mapped and gridded. Weed officer Trudy commonly uses the software ‘Aussie explorer’ to chart each rubber vine location, aided by a GPS running in the helicopter cabin. After locating the plant(s), a surrounding area is ‘gridded’ and checked to ensure it is rubber vine-free. Once the plant has been identified, a plan for managing and surveillance of each outbreak is quickly put into place. Weed officers now manage – visit and treat – 24 sites along these river systems as part of their annual workplan (running until 2017).

Using various devices to enhance their own seeing and sensing capacities, these plant managers are thus responding to the particular materiality and mobilities of rubber vine – the creeping presence in the landscape, the gloss on a leaf. These responses involve considerable skill, and accumulation of detailed knowledge of the plant as well as the broader landscape. They must be maintained over temporal cycles that intersect with the plant’s life cycle to be effective.

**Entangling with others**

In the process of embedding itself among other plants, and eventually becoming the locally dominant vegetation, rubber vine forms relationships with other nonhumans, including animals. Arthur, a local district weed officer in the containment zone in Queensland, described at length how feral pigs and wallabies forage out on the grassy plains during the day and then shelter underneath the matted vines at night. According to Arthur the wallabies have now successfully bred into very large populations, completely displacing smaller species. Arthur the wallabies have now successfully bred into very large populations, completely displacing smaller species. Arthur explained that the aims of these demonstrations were to restore river access for the owners’ cattle, as well as to convince landholders of the cost and labour efficiencies of this technique.

Aerial ignition burning allows managers to target rubber vine towers and is an adaptation of a bushfire management technique whereby a helitorch is used to backburn ahead of an unmanaged fire front (ESC 2011). For burning, gelling agents are mixed with petroleum to create a ‘low flash point, highly volatile fuel’ slung in a helitorch below a helicopter (ESC 2011). This gelled petroleum ignites at about 320°C, but for rubber vine management the aim is to burn when vegetation fuel loads and weather conditions will heat the fire to above 600°C – the point at which the latex in the rubber vine will ignite and kill the plant.

Early in the morning, we met Arthur and Craig, the weed manager, landowner, Queensland. There was no mention of eradication. The bushy rubber vine sitting away from the river was not to be targeted; their more open structure makes them difficult to burn, and setting fire to those further from virtually impossible to push a horse through it, and if you’ve got scrubber bulls it’s dangerous. Well, yeah, it is dangerous on the ground. The boys can get them out but they’ve got to know what they’re doing and they need to be experienced. So yes, it can create mustering problems. (Daryl, weed manager, land owner, Queensland)

In the tangle of vines, where does one plant begin and another end? For these managers, the mass of individual plants becomes the collective they have to deal with, in contrast with other experiences in the eradication zone where spotting rubber vine individuals provides the management focus.

**Latex as shifting mediator**

Depending on the density of infestation, different combinations of chemical, mechanical, biological and fire control techniques are used to manage rubber vine. It is possible to burn rubber vine from the ground, but for large and remote properties burning can also be done from the air. We observed aerial burning demonstrations on two properties in the control zone in the Gulf of Carpentaria in late June 2012. The targets for the burn were rubber vine towers on inter-channel islands along a seven-kilometre stretch of the Einasleigh River, each tower a once mature eucalypt tree now standing dead, or collapsing under the weight of smothering vine. Arthur explained that the aims of these demonstrations were to restore river access for the owners’ cattle, as well as to convince landholders of the cost and labour efficiencies of this technique.

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Early in the morning, we met Arthur and Craig, the helicopter pilot, on Arthur’s back veranda over coffee. Annotated topographic maps were spread across the table; the entrance gates and mixing site were circled, and the sites to be treated along the river channel noted. Arthur had checked the weather forecast and judged it to be pretty good – 30°C and a light breeze. The relative humidity was just lower than the temperature (27%), making it safe enough to burn.

There was no mention of eradication. The bushy rubber vine sitting away from the river was not to be targeted; their more open structure makes them difficult to burn, and setting fire to those further from
the river also runs the risk that the fire will escape and burn valuable pasture. Preparation work for the burn began a few weeks before. Arthur and the owner did reconnaissance along the various treatment sites to check vehicular access, mark out a ‘mixing site’ for the helicopter to land and refuel safely, and assess the ‘fuel’ load (or grass cover) underneath the rubber vine towers. Enough grass cover helps to get the fire started, but too much will allow fire to escape into surrounding country. For this burn, the property owner had taken the cattle out of the paddocks 12 months previously to get decent grass cover. In the previous week, with the weather forecast available, a burning permit from the local fire warden was arranged through the local police station.

In the following days we watched Craig manoeuvre the chopper around the towers of vine, angling it so the ignited fuel dripped from the swinging helitorch onto the towers below. Plumes of smoke rose steadily, and within minutes of ignition brown kites came circling in for a look, posing an additional danger for the helicopter. Craig flew in widening circles over each inter-channel island, keeping the helicopter out of the smoke plume and maintaining visibility. The fuel canister, filled with a two-part gelling agent mixture adjusted for heat and humidity, was reloaded three times during an afternoon’s work.

After burning was complete, we flew with Craig along the river line – visible in the distance by rising smoke threaded along it (Figure 3). Although still smoking, the fires were essentially out. Very little surrounding vegetation had burnt, but the thick basal stems of targeted rubber vine were burnt through and everything on top would now die off. A helicopter and hundreds of litres of potentially explosive fuel initially seemed like a very blunt instrument, but we were left with strong impressions of the targeted and controlled nature of the burn, and of Craig’s calmness and skill.

William, an ecologist who has been studying the effects of this burning approach over the past three years, explained later that the key is understanding the conditions and how they will interact with the latex.

It’s just burning. But what happens is that when you get sort of mass destruction it starts igniting, it gets hot enough to . . . ignite . . . the latex . . . and if you get that . . . green rubber vine will just burn through that, but it’s getting it to that point in the wet season that was a problem. But you can kill rubber vine with quite a slow fire. You don’t need a raging inferno to kill it. So at this time or later in the dry season you can kill it with a very steady backburn and it will just run through and the flame heights will be really low and quite manageable. And really that may not even burn the canopy at all. (William, government weed ecologist)

The demonstration burns we witnessed will kill as much as 80 per cent of the vine biomass that was ignited, which pleases Arthur. He has struggled to convince the bureaucrats that new methods, more maps or more meetings are not needed – instead, what is required are people on the ground and consistent funding. We learn later that the owner was also happy with the aerial burning. On his property – average for the district at approximately 480 km² – a seven-kilometre stretch of river was done in just three to four hours, work that might otherwise have taken three or four men a week of burning from the ground. The longer term aim of opening up spaces among the vines to improve pasture grass cover will depend on follow-up burns in the years to come. A successful demonstration then, but managing rubber vine requires ongoing vigilance.

Rubber vine: capacities and agencies

Rubber vine illustrates the lively capacities shared by plants, and it does so in its own specific ways. It takes varied bodily forms, energised by its capacity (and need) to eat the sun. It lives and takes shapes in ways beyond relations with humans – for example, in producing latex that protects from herbivory, enlisting wind and water to aid its dispersal, or creating the branching whips by which it grows, entwines and spreads. Rubber vine moves without humans at scales across zones, pulls people off horses, provides refuge for animals. It senses and responds with various parts of its bodies. The agency of the plant is clear; rubber vine is not passive.

The variety of practices demonstrated here show that people already engage with rubber vine as a subject. It is read as a threat, and is implicitly recognised through the need to legislate, both as part of a group (invasive plants) and as a named individual species (in WoNS). Humans and other animals live with rubber vine, adjusting their lives and strategies while also working to affect rubber vine manifestations. This
particular plant has transformed biosecurity practices in very specific ways, urging on the use of helicopter searches and fire for instance. From the human perspective, this management strategy is also only possible with exceptional skill and technology, in very particular places. These practices are not used against other weeds because they would not be effective. The differences of rubber vine from other plants are clear. Burning as a management practice is only effective and possible in this way due to the combustibility of latex within the plant, in combination with its habit of climbing and forming dense ‘fuel’ concentrated towers that can be seen and targeted from above. So the materiality of latex, which evolved in a particular context, is now used by humans against the plant as part of their relationship with it – in fact in order to kill it. The pragmatic human response to the relationship also recognises that long-term victory is not possible if conceived only as eradication. Rather, the plant’s resistance to invasive plant management is acknowledged. Instead, from the human point of view the relationship is about setting priorities, protecting assets and adapting to the plants.

Our argument is not that rubber vine stands for all invasive plants, nor that invasive plants stand for all plants in discussing relations with humans. We have drawn attention to the differences of rubber vine from other plants, and how these differences have drawn specific human biosecurity responses. However there are some consistent trends; as an assignee to the category invasive plants, rubber vine illustrates some of the contradictions these plants pose to human understandings of plant mobility and sensing. When acting as ‘invasives’, plants are understood to be not only mobile but aggressively so, marching across whole landscapes. In the process, they marshall a range of sensing and communicative capacities. Their agency is clear but aggressively so, marching across whole landscapes. To be clear, we do not consider these or any other qualities to be intrinsic; they are themselves relational. Relations can solidify into particular forms and processes and endure over evolutionary and shorter timescales. They can also be disrupted, fall apart and be reconfigured.

These points apply to humans just as much as plants, so part of the value of such an approach is that it helps us reflect on our ways of living and knowing. As Kohn argued, the reason this work matters is not just that it gives voice, agency or subjectivity to the nonhuman – to recognize them as others, visible in their difference – but [that it forces] us to radically rethink these categories of our analysis as they pertain to all beings. (Kohn quoted in Kirksey and Helmreich 201, 562–3)

Plants challenge thinking about agency and subjectivity against a human norm; in contrast to many animals, plants are so different from us that we are not at risk of confusion. The point is not that plants possess agency, but that they enact distinctive agencies – sun eating, mobile, communicative and flexibly collective. So far, in the context of invasive plants, human engagement with such agencies shows an interplay between object and subject, depending on the circumstance.

Rubber vine has helped ground our conceptualisation – not that each capacity is highlighted in a way that can be listed, but each is involved and several are particularly prominent. Rubber vine forces us to rethink the individual – in a tangle of vines, where one plant begins and another ends is not always obvious. It manifests as two very different bodily collectives and demonstrates strong agency in both. It is highly mobile – spreading unseen or undetected, adapting its reproduction and overtaking other plants. People interact with it as an adversary; a problem to be eradicated, a species to be regulated, an impediment to mustering and a non-native.

Smaller categories under the umbrella of plant (tree, species, seed, invasive) also have ‘unshared’ capacities that must be examined in empirical specifics. We have shown how they are brought to bear in the wider set of relations that constitute the management of rubber vine as an invasive plant in northern Australia. We have traced the difference that non-human difference makes in the environmental governance of biosecurity. If plants were understood not just as things that can or should be ‘done to’, but rather things that act back – in partnership and conflict – policy would (and should) look rather different. Policymakers could first learn from the experience of practitioners on the ground where, as our empirical results showed, people are very conscious of plant capacities and affordances.

Conclusions

We have argued that it is timely for geographers to more systematically explore the differences and similarities of plants enacted with other beings. Drawing on recent botanical understanding, we have conceptualised the capacities of plants as shared and differentiating, pre-dating humans and changing in interaction with them. We outlined these capacities as including a particular materiality; mobility (without human intervention); sensing and communicating; and taking shape as flexible bodies. To be clear, we do not consider these or any other qualities to be intrinsic; they are themselves relational. Relations can solidify into particular forms and processes and endure over evolutionary and shorter timescales. They can also be disrupted, fall apart and be reconfigured.

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We have extended previous work on conviviality and mutual flourishing by focusing on an adversarial example. In fact the ethics of death and killing are never far from human–plant relations, whether it is weeding, eating, biosecuring or harvesting. In this way plants have much to offer ethical discussions by taking us beyond the avoidance of death as the preferred baseline. In the rubber vine example, humans have become very attentive to the ways in which these plants live and proliferate, as well as altering their own practices in order to become more effective killers. Rubber vine is also a killer of other plants and animals, so it is necessary to think explicitly about killing and killability, but in very different ways from a moral extensionism argument in which human sentence or consciousness remains the yardstick. (This argument is already widely considered problematic in relation to animal ethics (Whatmore 1997; Wolfe 2008).)

The combination of ethnographic approaches and methods of botanical sensing used in this paper has by no means broken free of ‘the magnetic attraction of the human core’ (Hitchings and Jones, quoting Jones and Cloke 2002). We recognise an epistemological tension in our case study in that we have approached human–rubber vine relations through the human lens. There is an important conversation to be had about whether we can do otherwise, and much more work is needed in this area. We consider this tension to be a productive one. The scale of our approaches – bodily, local, grounded – offers an important way to analyse the intricacies of practices and relations within anthropos. It thus helps heal the traditional biogeographic disconnect between the invisibility of invasives within biomes, yet their conceptualisation as continental invaders. We as researchers – like invasive plant practitioners – need to expand our ways of sensing in order to gain further insights into plant worlds.

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Notes

1 Some beings other than plants perform photosynthesis – for instance, algae.
2 For fuller discussion of the evolution of these capacities, including exceptions, see Head et al. (2012, chapter 2).

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