COMPARING INVASIVE NETWORKS: CULTURAL AND POLITICAL BIOGRAPHIES OF INVASIVE SPECIES*

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ABSTRACT. Under what cultural and political conditions do certain species become successful invaders? What impact does species invasion have on human culture and politics? The work assembled in this special issue of the Geographical Review suggests complex interspecies interactions that complicate any answer to these questions. It demonstrates the need to advance a more integrative human/environment approach to species invasion than has hitherto been seen. Reviewing the concepts demonstrated in these articles and applying them to case histories of Mimosaceae (a family that includes genera such as Acacia, Prosopis, and Mimosa) invasion, two general principles become clear. The status and identification of any species as an invader, weed, or exotic are conditioned by cultural and political circumstances. Furthermore, because the human “preparation of landscape” is a prerequisite for most cases of invasion, and because species invasions impact local culture and politics in ways that often feed back into the environmental system, specific power-laden networks of human and nonhuman actors tend to create the momentum for invasion. It is therefore possible to argue a more general cultural and political account of contemporary species expansion: It is not species but sociobiological networks that are invasive. Keywords: invasive species, Mimosa tenuiflora, Prosopis juliflora, sociobiological networks.

Invasive species seem to be everywhere these days. Although plant species invasion—the secondary distribution of plants in areas where they are not native (Pyšek 1995, 71)—has long been considered an important, albeit complex, problem in conservation science (Elton 1958), it is now more prevalent than ever. Invaders are increasingly evident around the world as the growing mobility of people and trade goods accelerates a longstanding process of contact and introduction.

Much is known about the character of these invasions. Most contemporary scientific investigations of invasion are inquiries into the inherent characteristics

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of invasive species. To a lesser degree, scientific research has also tried to expli-
cate the characteristics of environments into which invasives successfully expand.
Some species tend to be invasive; some landscapes are, or can become, more
invadable.

This understanding of the character of species invasion is certainly sound and is
based on good science and long-term observation (Newsome and Noble 1986; Roy
1990; Rejmánek and Richardson 1996), but it is somewhat incomplete. What causes
a species to be labeled as “invasive” by individuals, communities, and states? Why
do some invasive species spend long times in moderate rates of spread, only to
suddenly expand with changes in social or economic conditions? How do invasive
species come to interact with humans in such a way as to accelerate or decelerate
their rate of expansion? What cultural and political conditions make a landscape
invadable or tend to lead to species introduction in the first place? In the modern
model of invasion—modern in the sense of both “contemporary” and “modernist”
in outlook (Latour 1993)—based on the growing body of solid biophysical research
on the problem (see especially Pyšek, Jarosik, and Krucera 2002), the answers to
these questions are considered somewhat contingent, where the introduction of
inherently invasive species to invadable landscapes is seen as an accident of history
—the right plant, in the right place, at the right time—perhaps accelerated in this
contemporary era of contact.

The work introduced in this special issue, empirical case studies from a range of
social and environmental contexts, aims to improve and expand the research on
species invasion and refuses to accept the social parameters of invasion as nonsys-
tematic, contingent, and random. Rather, these cases show the patterned and struc-
tured character of invasions in a number of contexts.

This essay seeks to consolidate and expand on this work. The article first re-
views what is referred to here as the “modern model of invasion,” collective wis-
don from decades of work in the biophysical analysis of species invasion. Based on
the work presented in this collection, the article then offers an alternative formul-
tion suggesting that cultural and political ecology may advance and improve this
model by better specifying the way human and nonhuman systems interact. Spec-
ifically, the argument follows these several authors in suggesting that the very
definitions of “invasion,” “invasive,” and “exotic” must be considered somewhat
relative and heavily influenced by culture and politics. We also argue that because
the human “preparation of landscape” is a prerequisite for many cases of invasion;
and, because species invasions impact local culture and politics in a way that often
leads to changes that in turn influence environmental systems, specific power-laden
networks of human and nonhuman actors tend to create the momentum for inva-
sion. Finally, this approach is applied to two cases of Mimosa species invasion in
Asia and Latin America, demonstrating the portability of the key lesson learned
from comparative invasion studies: It is not species but sociobiological networks
that are invasive.
THE MODERN MODEL OF INVASION: “RIGHT PLANT, RIGHT PLACE, RIGHT TIME”

The study of species invasions is one with an impressive history, rooted in the exigencies of land management but growing into a basic science in its own right. As field observations and longer time series have evolved, controlled experiments and pseudo-experiments have begun to sketch a sophisticated biology of invasion. In the United States, Africa, and Australia many large, enclosed areas have been examined over long periods, as at the Idaho National Engineering and Environmental Laboratory, a sagebrush (Artemisia) steppe divided into control plots and observed since 1950 (Anderson and Inouye 2001).

The resulting empirical data have advanced an account of species invasion that explains twin facets of the problem: the invasiveness of specific species relative to others and, to a lesser degree, the invadability of specific landscapes. Together these have formed an account of invasion. Invasion occurs where invasive species encounter invadable landscapes.

INVASIVENESS

Plant introductions are more likely to become successful invasions when the introduced species reproduce in large numbers and disperse offspring over relatively large distances (Richardson and others 2000). Invasive species also tend to exhibit any of several specific features: adaptability (Pyšek 1995), aggressive reproduction (Baker 1974), and vigorous growth (Baker 1965).

Adaptability refers to the range of conditions under which a species might thrive (Pyšek 1995). Invasive species are adapted to a range of conditions that vary over space: aridity/humidity, direct/indirect radiation, and varying edaphic conditions. They often tolerate changing conditions over time, in terms of intra- and interannual variability in rainfall and radiation. Although some species may go dormant—for example, during stress periods—invasive species may be active, growing, or reproducing precisely when potential competitors are not. Species that occupy large geographical territories in their native ranges tend to make more successful invaders than do those with smaller ranges (MacDonald 2003, especially pp. 258–259).

Some species reproduce more aggressively than do others. Fast-seeding plants for example, with good adaptations for seed distribution, can quickly colonize new areas, especially after a disturbance event has removed competing species (Baker 1974). The vigor of growth shown by species is also important (Baker 1965). Fast-growing species seize sunlight and precipitation from slower-growing competitors.

These general characteristics have allowed biologists and ecologists to create a generic predictive profile of likely invaders (Newsome and Noble 1986; Roy 1990; Rejmánek and Richardson 1996). This has practical application for enabling quarantines and controlling the introduction and movement of potential nuisances.
INVADABILITY

Certain ecosystems are recognized as predisposed to invasion. That is, an invasion requires not only sufficient propagules of invasive species but also “a suitable microsite for germination and establishment to occur” (Hobbs and Huenneke 1992, 326). At the most obvious level, biogeographers generally agree that invasion succeeds in “environments that provide physical conditions that are well suited for the survival of invaders” (MacDonald 2003, 258).

No scientific consensus exists on the specific characteristics of invadable sites, however. Although invadability varies by ecosystem, and although moderate disturbance levels may thwart invasion and enhance native biodiversity, invadable landscapes do tend to be heavily disturbed (Hobbs and Huenneke 1992) and to have simplified plant communities with relatively less native biodiversity (Timmins and Williams, 1991; Pyšek, Jarosík, and Krucera 2002). Depending on the climatic and edaphic conditions, the level and type of landscape fragmentation may also accelerate invasion (Saunders, Hobbs, and Margules 1991). For these reasons, invasion is common along roadsides and trodden paths, in riparian habitats, on sand dunes, and in some light forests (Elton 1958).

Because many of these features can broadly be captured under the terms “heavy disturbance” and “land degradation,” the modern account of invasion may be simplified into the assertion that when the right species is introduced into a degraded environment, it is likely to become invasive (Johnson and Lewis 1995). Where long-term human disturbance is in evidence, as in the Mediterranean, invasion can be predicted (Groves 1986). Inversely, where adequate cover of native species is rich and dense enough, many otherwise vulnerable landscapes, especially semiarid communities, are more resistant to invasion (Anderson and Inouye 2001).

Together, these two components form the modern model of species invasion. Invasive species in invadable environments tend to dominate quickly over extended areas (Figure 1). The right species, at the right place and the right time, become broadly distributed, crowding out previous covers. Given these conditions, invasions are expected to occur at a fast but nonlinear rate, following a predictably unidirectional acceleration. Joan Roughgarden (1986, 181) states, as a prominent example, that the “square root of the area occupied by species increases linearly with time.” More complex and multilineal accounts of invasion have been asserted in conservation biology, and the complex role of genetics and invasive variability in populations and species has also been increasingly considered (Allendorf and Lundquist 2003). The essential conditions, exactly when invasive species are likely to encounter invadable landscapes, continue to be treated as contingent, however.

TOWARD A CULTURAL AND POLITICAL ECOLOGICAL ACCOUNT

However intuitive and compelling, something about this account is incomplete. The human elements of the problem are overlooked, in terms of both the patterned behaviors of people in setting the conditions for invasion and the impact of invasions on human history. Some species only invade rapidly when human conditions
or disturbance regimes shift and where social conditions change, for example. As a result, an emerging body of research has begun to attend to species invasion as a social process, with specific consideration of the humanized natural history of invasion (Hall 2003).

Even amid this analysis questions remain, especially concerning the power-laden circumstances and divided political and economic conditions into which an invading species arrives. Some species and communities, including human groups, benefit from invasion; some lose. Some adapt well to changing conditions; others do not. As a result, invasions are often closely integrated with political and economic forces, unleashed in struggles for control of resources. As Alfred Crosby observed in his now-classic Ecological Imperialism (1986), the “portmanteau” biota that accompanied European migration to Australia and the Americas paved the way for European transformation and control of the land, and vice versa; dandelions, grazers, and the plow together account for the success of the ecological transformation, not any one of them alone. “The success of portmanteau biota and its dominant member, the European human, was a team effort by organisms that had evolved in conflict and cooperation over a long time” (p. 293).

What can be learned, then, if we extend Crosby’s historical- and continental-scale lessons to current environmental changes and invasions at a smaller scale? How might a more structured typology of “portmanteau” conditions be outlined and a more general political ecological theory of invasion be derived? Certainly, the attempt would necessitate an examination of complex cultural and social institutions, like the labor required for weeding, the economics involved in land degradation, and the contested cultural definition of “invasives” themselves.
Consider for example, Louis Awanyo’s (2001) account of species invasion in Ghana. His analysis shows that the thick-growing, fast-germinating weedy plant kra wo ni (Chromolaena odorata), probably native to the Americas, is spreading at a rapid pace and overtaking farm fields. Clearing and weeding kra wo ni, and species associated with it, are major agricultural tasks in the region. Those households that are financially unable to seize and control labor for the task of weeding cannot maintain production. Coupled with tighter margins in nonsubsidized agricultural production, these households are driven to increasingly marginal positions in the regional economy, potentially reinforcing the spread of the species, or perhaps leading to accumulation of more land by larger landholders (Awanyo 2001). Whether the state recognizes and defines this species as an “invader” and responds will be determined in part by local politics as well as the pressures of international market and development aid. The political economic system links nonhuman species to socially stratified human communities, both allowing for and accelerating invasion.

Abstracting from the case studies provided in this issue, it would seem that “invasion” occurs by defining an event as an invasion, laying the framework in a landscape for invasion, and setting the social and economic terms for the uneven impact of an invasion on human communities, with human responses that may accelerate the incidence of invasion.

DEFINING THE INVASIVE

Although the appearance of an exotic species may be an empirical fact, the definition of an “invasion” usually depends on the perception of a species as pernicious—an assignment of culturally specific meaning. Consider the spread of North American lawn turf grasses, almost all of which are exotic and many of which are aggressive (Robbins and Sharp 2003). As most of the contributors to this issue emphasize, echoing assertions in environmental history and the biosciences, this interpretation and assignment of meaning is value laden (Gröning and Wolschke-Bulmahn 2003).

Lesley Head and Pat Muir demonstrate that even indigenous species can behave in an invasive way, though whether they are perceived as problematic is culturally loaded and variable. Their study further underscores that responses to a species’ invasiveness and its indigenousness are distinct: Some Australian backyarders welcome invasive behavior as “nature doing its own thing” but are less sanguine when a species is exotic, for example. The vernacular understandings of Pittosporum (indigenous) and Lantana and Cinnamomum (exotic) species vary between those who perceive invasion through a lens of indigenous “purity” and those with more “pragmatic” views. All of these are prefigured in the context of Australian nationalism, which sets the conceptual terms for defining and understanding insiders and outsiders (Olwig 2003). At the same time, such perceptions are geographically and historically dynamic. Pittosporum is defined as threatened in its native habitat but regarded as invasive elsewhere. Derek Alderman’s study finds that kudzu went from being a welcome savior of the depression-era U.S. South to being its scourge in the space of a few decades.
None of this is to suggest that the biophysical processes of invasion do not occur if humans do not recognize the event as an invasion. Rather, it underlines that action, reaction, adaptation, and control measures are predicated on the interpretation of species and their role in the ecosystem. The first key component of invasion is the culturally and politically laden recognition of species as an “exotic,” “foreign,” or “invasive.”

LAYING THE FRAMEWORK FOR INVASION

The articles here also underline the way in which the ground is “prepared” for invasion. This preparation may occur either physically, by increasing the invadability of the landscape through disturbance, or socially, by creating conditions to enhance the success of invasion. These issues of preparation help suggest an answer to the riddle of why species invasions occur when they do, and why long-term invasions can suddenly accelerate.

In the first case, many land-management practices (for example, fire) directly increase landscape invadability. So too, the geometry of modern land management may further accelerate the process. The scientific literature suggests, for instance, that fragmented habitats with high edge:area ratios, exactly those of most modern urban environments, may influence the rate and success of invasions (Hobbs and Huenneke 1992).

But more than this, a pattern of heavy human use and impact, followed by abandonment, recurrently leads to invasion. Bracken fern in the Yucatán, as explored in Laura Schneider’s case study, favors land that has been cleared by people for production and is later abandoned. Clearing the canopy layer is essential to give the invader light; abandonment leaves areas open to rapid change without human response. The same is true for Jennifer Foster and Anders Sandberg’s case study of Toronto’s Don Valley Brick Works. Hence, “wasteland” (itself a contentious term; see Brara 1992; Robbins 1998) or any land under contested or lapsed control, ownership, or authority, is susceptible to invasion, especially after long histories of continual use.

This pattern of established land-use practices that, once ended or disrupted, enable the sudden expansion of invaders is common to invasion histories. Alderman’s kudzu spread slowly in the rural South as long as grazing was open and general. The modernization of livestock management meant reduced forage pressure and allowed a dramatic increase in the incidence of the weedy vine. Head and Muir’s Lantana camera invades backyards retired from continual, long-term grazing.

Land-use and land-cover conversions are not the only forms of preparation. Social and cultural preparation is also a common prerequisite. The question of defining invasives as such in the first place is by no means materially irrelevant, for it influences human response and determines the resources dedicated for the protection or eradication of species. As Stuart Kirkham’s case study suggests, species invasions are presaged by a “social preparation of the landscape,” which in Samoa is reflected in the differential social power of expert ecologists and local farmers in defining the terms and desirability of Merremia peltata.
Economic preparation of the landscape works in a similar fashion. Alderman suggests, for example, that political economic conditions of the South shifted in the mid-twentieth century along with related land-cover demands. This created a new resource economy hostile to kudzu: reduced grazing and increased forestry. One might therefore argue not that kudzu invaded southern forests but that forests invaded southern kudzu. The case of kudzu also underlines the importance of strong, charismatic, or bureaucratically powerful agencies and people in introducing species in the first place. Channing Cope single-handedly established a new culture around kudzu as a “miracle vine,” which would be overturned only after the plant had made a terrific nuisance of itself. Many invasions begin from similar stories of ecological improvement (Robbins 2001).

WINNING AND LOSING SPECIES AND COMMUNITIES

Finally, the ecological, economic, and political context into which a species invades invariably leads to differential effects on people, animals, and other plants. These uneven effects may create opportunities for “alliances” between invading species and various human and nonhuman actors that are simultaneously benefited or empowered by the invasion. The rate of invasion may accelerate, therefore, through positive cultural and political feedbacks.

Foster and Sandberg’s examples of invasives in Toronto public spaces point to the myriad but highly directed benefits of invasion. The success of Canadian thistle at the Don Valley Brick Works is linked to the perception and use of the place by an elite, dog-owning community. Middle-class elites, dogs, and the thistle work together to change the landscape. Landowner tolerance of Lantana in Head and Muir’s examples of invasives in Australian backyards is similarly enhanced by the plant’s ability to provide bird habitat, which some people desire. Any effort to restore “native” species (an increasingly common mission; see Smout 2003), therefore, must inherently take sides in ongoing political struggles.

The classed and gendered distribution of these effects is even more clearly demonstrated in Kirkham’s example of Merremia peltata. The perception held by some local producers, especially men, that M. peltata cools the soil and suppresses other weeds is treated as more authoritative than contrary accounts, specifically those of local women. The convergent benefits for the species and these farming men perpetuate the invasion.

State institutional strength and fragility also hold implications for thwarting or accelerating species invasion, although their effect is contextual. Where state authorities seek extermination of species but their legitimacy is low, little action may be taken by local land managers, leading to more rapid invasion. But where state mandates include the planting and protection of exotic species, strong authority may accelerate invasion. The degree to which the species is linked to legitimate authority largely determines invasion outcomes. Conversely, where invasion threatens only politically and economically marginal people, animals, and plants, it may remain altogether uncontested or undefined as an invasion.
The ability on the part of land managers to combat invasion is also politically and economically conditioned. As Foster and Sandberg point out, the material costs of “naturalization”—a return of conditions to preinvasion status—can be quite high, and thus differentially available to groups with power and resources. Restoration of Toronto’s High Park is therefore a power-laden and classed act. As Schneider shows in the more complex case of the Yucatán, land-surplus conditions result in high labor costs and prohibitive expenses, whereas land scarcity raises the marginal value of the labor effort to control bracken fern. It may further be suggested that uneven distribution of landholdings and land control, as is common under modern conditions of underdevelopment, holds direct implications for changing rates of species invasion in the contemporary era.

For both human and nonhuman species, therefore, the uneven distribution of costs and benefits of invasion ultimately leads to differential responses, either acceleration or deceleration of invasion. Existing socioeconomic inequalities further condition the capacity to respond.

**Application of the Cultural and Political Ecology Approach**

Together, invasion definition, social preparation for invasion, and uneven distribution of invasion effects among people and other species indicate a cultural and political ecology of species invasion. Specifically, they suggest that the meaning applied to species, the social and economic conditions of landscape preparation, and the social and political ability and willingness of other species and communities to respond to invasion are configured by how well networked the invading species (whether exotic or indigenous) are in social ecologies.

The following two brief case histories of invasion further illuminate the systems of interactions that form persistent networks of invasion. Brazilian jurema (*Mimosa tenuiflora*), an aggressive leguminous plant with psychedelic properties and sacred uses, went from being the bane of European colonial authorities to a globally recognized medicinal investment and popular agroforestry-plantation species, now occurring over increasingly large areas. Mexican mesquite (*Prosopis juliflora*), a declared nuisance in North America, has expanded rapidly in Africa and Asia with the help of global development authorities. Comparing the social and economic geographies in which these arid-land species are enmeshed and through which they are propagated leads to a more general account.

**Mimosa tenuiflora**

Occurring under the common names *calumbi, jurema preta, carbon chele, carbon negro,* and *tепесcohuite,* Brazilian jurema commonly falls in the category of “quarantine weed” around the world, a status that makes its importation illegal or highly controlled. It occurs in dry thorn forests, in thickets, and in pure stands, especially in abandoned or degraded lands. The species is broadly viewed as beneficial, because it has a range of uses, including as fuel, as fencing, in healing wounds and burns, as soap, and in industrial products. Even so, the species is invasive, is com-
mon along roadsides and in fields, and expands at a rapid pace. It can be found not only in Brazil but increasingly in other regions as well. Some of its accelerated expansion is recent, however, and its introduction to invadable environments is part of a broader political economy of invasion.

Though native to the wet tropics, jurema is a heat- and drought-tolerant species found in even the most arid conditions. Adapted to a wide range of climatic and edaphic conditions, its contemporary range falls far outside its native Brazil, extending to Colombia, Venezuela, El Salvador, Honduras, and northern, central, and southeastern Mexico (Barneby 1991). The growth and distribution of its fruit and seedlings are fast, as they are disseminated by wind and commonly carried downslope by rain and human activity. Together, the abundant production of seeds, their fast germination and growth, their taproot system, and their compound leaves (whose leaflet orientation changes in response to light) make *Mimosa tenuiflora* an aggressive and potentially invasive species (Camargo-Ricalde and Grether 1998). It tends to dominate cleared land and to slow the recovery of forest areas cleared for agriculture (Pereira and others 2003).

Since prehistoric periods, jurema has been cultivated for medicinal and culinary uses. By the tenth century, indigenous healers were already using the plant to treat skin lesions. The plant and bark contain trace amounts of N, N-dimethyltryptamin (DMT) and so were traditionally brewed to produce a psychedelic substance for trance possession rituals associated with warfare (Schultes, Hofmann, and Ratsch 1992). For this reason, the species and its use declined with the advent of Jesuit missionaries in the region during the eighteenth century. This was further reinforced by the more general pattern of “extinction” (more accurately described as dispersal and land seizure) of ethnic groups in the 1900s. At this time, jurema-related cultures and rituals syncretized with Christian and African practices and went into decline.

Although the plant continued to spread and hybridize across the region, it did so at a slow and steady pace. It is now found from the Amazon to as far north as the Mexican state of Oaxaca (Barneby 1991). Despite its potential value in terms of nonwood forest products, thickets of the species, which expand along roadsides and into pastureage, have often been considered a nuisance.

The historical spread of the species is facilitated by a set of alliances that assure its propagation. The use of the species in regional fallow systems under conditions of intensification and disturbance and the globalization of agroforestry expertise and experimentation have together aided in the establishment and expansion of the shrub.

In the first case, intensification and disturbance have radically increased the presence of secondary forest growth in Central America. The dry forests of Honduras and Mexico have experienced significant and accelerating rates of deforestation (Janzen 1988). As ranching and agroindustry have come to dominate lowland regions, small farmers have been driven to hill lands (Durham 1979). There, land has been subdivided, and primary woodlands have been cut back. Increasing demands
placed on subdivided fields lead to an increase in shrubby secondary growth of quick-growing communities, including *Mimosa tenuiflora*.

Concomitant pressures on more intensely cropped lands have led simultaneously to exhaustion of soils and declining productivity. In response, the “carbon negro” fallow system of central and southeastern Mexico provides a means of compensating for lower soil quality by taking advantage of secondary succession on marginal lands. These fallows develop the association of *Mimosa tenuiflora* with maize and sorghum production, encouraging the spread of the species. Biologically and economically enriching the soil through nitrogen fixation, *M. tenuiflora* is tolerated, though rarely sown, by local farmers (Kass and Somarriba 1999). The tree bark is also increasingly used for traditional healing and skin care (Camargo-Ricalde 2000).

At the same time, global searches for leguminous species in land reclamation have meant that *Mimosa tenuiflora* is increasingly popular among scientific agroforestry organizations. Experimentation with the tree has resulted in its introduction to new territories (Franco and Balieiro 2000).

*Mimosa tenuiflora* spent most of its history networked primarily with traditional and politically marginal groups. Only by finding its way into disturbed environments resulting from land accumulation, into association with broadleaf “weedy” species, into the fields of farmers with increasingly strong demands for nitrogen, and into agroforestry organizations hunting for “wonder trees” has the tree become an ubiquitous Central American invasive (Figure 2). Significantly, the Brazilian Culto de Jurema has reportedly been revived in Brazil, especially in areas where insurgent populations are contesting land rights with the state. This may represent a further opportunity for the expansion of the species.

**PROSOPIS JULIFLORA**

*Prosopis juliflora*, or North American mesquite, is a quick-growing leaf xerophyte that accommodates transpiration losses and water shortages through leaf shedding; it grows under drought conditions where other species may not (Bogusch 1951). Animals do not usually browse its leaves, but the seedpods of the tree provide good fodder. The tree spreads through low lateral growth, forming a dense, head-high canopy within a few years (Lee and others 1992). Its long, lateral root system allows the tree to compete successfully with other species for soil moisture (Hocking 1993). *Prosopis juliflora* is nitrogen fixing, but recent research suggests that the leaves of the tree contain water-soluble allelopathic chemicals that halt the germination of competing herbaceous species, especially grasses (al-Humaid and Warrag 1998), under the canopy (Noor, Salam, and Khan 1995).

*Prosopis juliflora* has long been considered a nuisance and a sign of poor land management in its region of origin. Nevertheless, it is now a global weed and is expanding quickly. The expansion of the species in South Asia (Robbins 2001) is typical in many respects. A recent report indicates a 6 percent decrease in grass cover in the Banni area of the Indian Kachchh (Gujarat) from 1980 to 1988 associated with the expansion of *P. juliflora* (Jadhav, Kimothi, and Kandya 1993), making
it a major environmental problem in the region, along with erratic and scanty rainfall and salinity ingress (Mouat and others 1997). The specific drivers of the invasion again demonstrate multiple linkages that encourage species expansion.

The introduction of the tree has been aided and supported by powerful bureaucracies. *Prosopis juliflora* was originally introduced into the Sindh Province of India (currently Pakistan) in 1878. The maharaja of Jodhpur brought it to western Rajasthan in 1912 to “green” the landscape (Hocking 1993). This has been followed with extensive support by state agents whose land-cover targets are quickly met by the dense lateral expansion of the tree's canopy. The species is still being introduced in many parts of the region by state authorities, owing to its strong ability to develop a thick canopy quickly, enabling forestry bureaucracies to meet their planting and survival targets (Hocking 1993; Cronk and Fuller 1995).

Like other shrub invasions of savanna ecosystems, *Prosopis juliflora* expansion is associated with increased livestock-grazing pressure. This pressure is created, in part, by the enclosure of traditional grazing lands by state authorities, coupled with declines in available fallow resulting from land consolidation. *Prosopis juliflora* also tends to expand in combination with other invasives in the region, especially *Lantana camera*, an indigenous invasive, probably from central India. Together, these two species crowd out the local *Prosopis* species (*cineraria*), reflecting a form of cooperative ecological alliance. Moreover, *P. juliflora* benefits from the redistribu-
Fig. 3—Prosopis juliflora shrubs and trees (foreground) growing along heavily grazed goat paths on the flank of the Kumbhalgarh Wildlife Reserve in Pali District, Rajasthan, India. Increased grazing pressure has resulted from lost community pasturage, increasing the density of goats (center) in forest fringe areas and accelerating both juliflora seed dispersal and the removal of native vegetation. (Photograph by the author, January 2001)

tion of its scarified seeds in animal dung (especially that of goats), an important vector in its expansion. The increased reliance of goats on P. juliflora pods is partly a result of their increased availability but partly a product of decreased alternative fodder, owing to conservation enclosure and land consolidation (Figure 3). These mutually reinforcing trends help establish the species sociopolitically as well as ecologically (Figure 4).

An Alternative Model of Invasion: Invasive Networks
These two cases, like the other case studies in this issue, suggest important lessons for the biogeography of secondary succession, invasion, and biotic community change. They underline that environmental settings are arguably both natural and social, rendering this modernist distinction unhelpful (Latour 1993). They also underline the fact that even desirable plants can be considered weeds under certain
Fig. 4—The *Prosopis juliflora* invasion network.

conditions. Finally, they show that invasive species influence political and economic systems and that some political economies encourage invasion. The encounter of invasive species with invadable landscapes is not, therefore, entirely a product of historical contingency and accident; it is a tendency in systems of positive feedbacks in the socioenvironmental process. We can specifically hypothesize at least three processes that accelerate modern species invasions: the link between marginalization and disturbance; the incentives of modern ecological bureaucracies; and the tendency of species to expand in alliance.

The rate and acceleration of species invasion is directly linked to the networking of the invading species with allied species, land managers, and bureaucracies. In one Mimosaceae case, disturbance is exacerbated by upslope movement of poorer smallholders, linked to the expansion of agroindustry and land consolidation. In the other case, disturbance is increased as a result of scarcities produced through
conservation enclosure. But in both cases, processes of socioeconomic marginalization and disturbance have been essential to species expansion. In one case foresters sought canopy and encouraged planting; in the other, nitrogen fixation for agroforestry was the goal. In either case, organized modern ecological bureaucracies have been essential to species introduction. In one case the invader expanded in communities with local species; in the other the invader expanded with introduced species, but both expanded in alliance.

By comparing the social and economic geographies in which these arid-land species are enmeshed and through which they are propagated, it is possible to argue a more general political account of contemporary species expansion: Species may be invasive, but networks determine histories of invasion. A network in this sense (following Latour 1987, 179–180) is taken to mean simultaneously a process that gathers together, enrolls, and connects human and nonhuman actors (bureaucrats, trees, landowners) under its own momentum, a “fragile achievement” that emerges only when all of the actors are in place. This perspective follows recent thinking about using an actor-network approach to understand human/nonhuman interaction in geography and allied disciplines.

In an actor network, agency does not belong to individuals, organisms, or even species but instead is an emergent property, where the “capacity” of an object is imbued only by its position in a network of heterogeneous elements, a group of human and nonhuman allies. The cohesion of these groups is itself the result of the way each of its components is modified and transformed in its alignment with the network, a process that actor-network theorists describe as “translation” (Callon 1986). An actor-network approach is analytically useful because it breaks down traditional false binaries constructed between the character and power of human and nonhuman actors. Who is “at work” in the case of *Proopis juliflora*, for example, the trees or the foresters? To what relevant degree are their characteristics different?

The approach has strong explanatory purchase because it directs attention away from individual people, species, and habitats and toward their interrelationship. It suggests the way in which the characteristics of each of the individual actors is, in part, produced by the other. In the case of *Mimosa tenuiflora*, for example, how do each of the actors—including trees, missionaries, soils, and farmers—become the way they are? Only through their interrelationship. As Donna Haraway insists (2003, 6), “through their reaching into one another, through their ‘prehensions’ or graspings, beings constitute each other and themselves. Beings do not pre-exist their relatings.” Invasion is only one example of such mutual constitution, but it is a dramatic one.

Moreover, the approach helps to shed light on the specific power-laden social structural formations that connect and direct species invasion. We are forced to ask how strong bureaucracies, marginalized producers, and interspecies alliances are connected and how those connections become strong. Dwelling on connections, rather than on individual, atomized drivers, helps us to understand power, which, in a network model, as Jonathan Murdoch (1997, 737) observed, “lies not in the properties of actors but in the relationship established between them.”
Finally, such an approach refreshingly abandons any overarching “hierarchical program” in which large-scale actors come to dominate or explain the localized effects experienced by smaller actors (Latour 2004). A single species, a set of minute soil conditions, an opportunity created by highly localized disturbance regimes—all can build momentum to create regionalized effects, enrolling and transforming other actors. This scale-skeptical approach to social, political, and economic causes and effects more closely resembles that of ecological and evolutionary process (crucial for invasion studies) than do the hierarchically graded scales of causal power more typical of social science explanation, especially in the field of political ecology (Robbins 2004).

Such an approach to species invasion opens the door for future research, and most of the pressing questions are as yet unanswered. Do some specific network configurations prove to be more aggressive and longstanding than others? Do some configurations act to thwart or cope with invasions better than others? How have invasions influenced political and institutional configurations? All of these questions require more robust and long-term investigation than is possible in these pages, but the research introduced in this special issue of the Geographical Review represents a good model for that forward progress.

Note

1. Synonyms / other Latin names are: Acacia tenuiflora Willd., Mimosa cabrera H. Karst., M. hostels (Mart.) Benth., M. limana Rizzini, and M. nigra Huber.

References


COMPARING INVASIVE NETWORKS


