Urban Containment Policy and Exposure to Natural Hazards: Is There a Connection?

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ABSTRACT Planners throughout much of the past century have advocated containment of urban sprawl through regulatory restrictions that include growth boundaries, green belts and limits to utility extensions. Containment is widely practised in Europe and is a key component of ‘smart growth’ being advocated by a number of interest groups in the USA. In fact, it has already been incorporated in growth management policies in use in 73 US metropolitan areas. In this paper, we argue that containment may have a serious side-effect. It can lead to increased exposure to natural hazards and higher losses in disasters. However, we also show that measures are available to counter this effect, if planners recognize the threat and take vigorous steps to contain hazards, adjust building techniques or limit the development of potentially hazardous areas.

Introduction

Much debate centres on appropriate patterns of urban development. The pattern of development seen in the USA since the end of World War II and in Europe in recent years has been characterized popularly as urban sprawl. A growing number of scholars and professionals, however, are calling for more compact urban development, and an increasing number of governments have enacted policies to foster it, as Nelson & Duncan (1995) and Daniels (1999) document in their books on growth management techniques.

Up to this point, however, advocates of compact development have failed to recognize what may be a serious, unintended, consequence of containment: its potential to increase vulnerability to natural hazards. By limiting the amount of land available for development, containment policies can lead to higher land prices. This, in turn, can increase pressures to develop lower-priced hazardous land that was passed over in the initial wave of urban development. Hazardous areas particularly subject to intensified development include areas subject to coastal erosion, flooding (floodplains and coastal high-hazard and storm surge zones), ground failure (slide-prone slopes, earthquake fault zones and
liquefaction zones) and subsidence. In short, a by-product of containment policies can be increased exposure to loss of lives and increased property damage in natural disasters.

In the USA, natural hazards on average result in economic losses of approximately US$26 billion per year (Mileti, 1999). World-wide losses from natural hazards have been estimated at US$100 billion per year (Clarke & Munasinghe, 1995). These losses can be reduced if hazards are recognized in advance of exposure and appropriate measures are taken to counter their potential adverse effects. Steps that can be taken to reduce vulnerability include the preparation of hazard mitigation plans that identify the degree of risk and evaluate alternative courses of action, the adoption of building and land use regulations that reduce exposure to harm and investment in hazard control measures that reduce the onset of hazards. Counter-measures are expensive, however, and they are not likely to be employed without ample evidence of a real threat. This paper begins the process of providing this needed evidence.

We proceed as follows. The next section describes policies designed to contain urban growth and documents their increasing use in the USA and elsewhere. Next we examine the theoretical basis for our hypothesis that containment policies can increase vulnerability to natural disasters. We follow this with evidence that where urban expansion has been constrained, due either to natural barriers or to public policy, exposure to natural disasters is now recognized as a serious problem. We show, however, that this result might have been minimized had local governments adopted various preventive planning and management measures concurrently with their adoption of containment policies. The paper concludes with recommendations for steps that localities can take when they initiate urban containment programmes so that the potential for an increase in exposure to natural disasters is also contained. Because the evidence on which our argument is based is circumstantial, we also argue that additional research should be conducted to further substantiate the effects of containment on vulnerability and to suggest which counter-measures are likely to be most effective in limiting future losses.

Urban Containment Policies

Urban containment policies in the USA include a variety of regulations and public investments that attempt to constrain urban sprawl and create incentives for development in the central portions of urban areas (see Nelson & Duncan (1995) and Daniels (1999) for reviews of containment policies adopted by various states and localities). These policies include the enactment of regulatory urban growth boundaries, limits on utility extensions to outlying areas, the delineation of green belts and a variety of other measures. City and county governments acting on their own volition have enacted these policies, but increasingly state governments are mandating or encouraging them (e.g. Florida, Hawaii, Maryland, New Jersey, Oregon and Washington state). In this regard, the USA is following in the footsteps of urban containment policies pioneered in western Europe, where governments in Denmark, France, Germany, the UK and the Netherlands have mandated various measures to contain urban expansion (see Davies, 1989; Jenks et al., 1996).

The rationale behind urban containment policies is that unconfined growth can result in negative economic, social and environmental effects. Unconfined
growth tends to draw affluent home buyers and business into the suburbs, where land is more readily available and initially less expensive due to government subsidies (Bourne et al., 1978). According to Rusk (1993) this draws jobs and tax revenue out of the central city and makes it difficult for city governments to meet the costs of providing efficient public services. Peripheral growth also tends to concentrate poor residents and minorities in the inner city as educated, affluent residents move out (Bullard et al., 2000). The social effect of this movement is the creation of urban ghettos characterized by substandard housing, racial segregation and impoverished social environments that are outside and, increasingly, in opposition to the mainstream culture (Freilich & Peshoff, 1997). Unconfined growth also has environmental consequences, as development schemes eliminate green spaces that could be used for agriculture, wildlife preservation or outdoor recreation (Clawson, 1971). Unconfined growth could be seen as wasteful of energy, due to increased travel requirements, which in turn create harmful emissions from burning fossil fuels (Energy Information Administration, 1994). The pollution caused by these emissions contributes to possible health hazards and global warming (Intergovernmental Panel on Climate Change, 1995).

The intended result of urban containment policies is a compact form identified by high-density development (Hall et al., 1973). This form is intended to keep tax revenue and jobs within built-up areas of cities, promote neighbourhood social and racial stability, conserve energy and preserve green space outside cities (Knaap & Nelson, 1992; Nelson & Duncan, 1995). Indeed, Nelson (1999, 2000) (see also Jenks et al., 1996) has conducted research that provides evidence of these effects. Unintended, negative consequences from urban containment, however, have also been identified. These include: higher land prices as supply dwindles (Whitelaw, 1980; Nelson, 1985); lower environmental quality as density creates conflicts between environmentally intrusive activities and environmentally sensitive functions (Miller & De Roo, 1996; Troy, 1996); and lower quality of life as personal space, housing choice and privacy are decreased (Stretton, 1996).

The idea of containing urban expansion originated in the USA in the early years of the 20th century (Scott, 1969). The first formal urban growth boundary in the USA, however, was not adopted until 1958, when Lexington, Kentucky, put in place policies to limit urban development to a core area of 67 square miles, which it expanded to 75 square miles over the following four decades (Porter, 1997). Outside the boundary, residential density was limited to one dwelling unit per 10 acres. Three years later, in 1961, the state of Hawaii created the Hawaii State Land Use Commission to zone all land in the state into three classifications: urban, agricultural and conservation (see Healy, 1976). The state's primary goals were to curb urban sprawl and protect land for agricultural production (DeGrove, 1983).

During the 1970s, other states and cities began to initiate urban containment programmes. Oregon's 1973 Land Conservation and Development Act requires incorporated cities and urban areas of counties to draw urban growth boundaries and restrict the use of land outside the boundaries to rural activities (Leonard, 1983). Among Oregon cities subject to this law, Portland is pointed to most frequently for creating a model of urban containment. The Oregon State Legislature directed the regional Metropolitan Services District (Metro) in Portland to design and manage an urban growth boundary encompassing 24 cities

Since 1980, urban containment policies have been encouraged or mandated by the states of Florida, Maryland, New Jersey and Washington (Weitz, 1999), and have been adopted by cities in 73 metropolitan regions (Nelson, 2000). Table 1, based on a national survey of every metropolitan planning agency, provides a list of metropolitan areas, organized by state, which have some form of urban containment policy in place for one or more cities within the metropolitan region.

## Containment Policy and Exposure to Hazards

As land available for development is limited by an urban containment policy, one of the first effects of the policy is usually an increase in land values (Whitelaw, 1980). This initially leads developers to use land more efficiently, building housing and other projects at higher densities than before. Another potential effect, however, is pressure to develop land exposed to natural hazards that prior to the containment policy developers bypassed when looking for sites for residential and non-residential projects. This occurs for several reasons. First, as vacant land for development begins to become scarce, hazardous land may be the only property readily available. Secondly, because development constraints such as hazards should have been capitalized into land values, hazardous land should be the lowest-price land available, all other factors being equal. If developers invest in hazard mitigation measures, such as the elevation of structures in floodplains and the installation of slope-stabilization measures on hillsides, vulnerability to disaster may remain relatively constant. However, if local governments have inadequate land use regulations in place or regulations are inadequately enforced, developers are likely to avoid these costs (see Burby et al., 1997a).

The tendency of developers to avoid investment in hazard mitigation measures is explained, in part, by lack of consumer demand. Consumers have been found to place little value on such measures and are generally unwilling to pay for them, if they can avoid it (e.g. see Burby et al., 1988; Laska, 1991; Palm, 1998). Researchers have found that relatively few households retrofit their homes to reduce vulnerability to losses in floods and earthquakes (Laska, 1991) or purchase insurance to shield themselves from financial losses (Palm, 1998). Thus, one of the outcomes of urban containment may be added pressure for construction within hazardous landscapes with no preventive efforts engaged either during construction or after buildings are occupied.

## Urban Containment and Land Prices

Economic theory predicts that when land supply is constrained in the face of rising demand, land prices will rise. In the absence of constraints, land values
### Table 1. US metropolitan areas with urban growth boundaries, by state, 1999

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Source: Arthur C. Nelson, City Planning Program, Georgia Institute of Technology, Atlanta, Georgia, based on national survey of metropolitan planning agencies completed in December 1999.

...decline at a declining rate from the centre of an urban area. If one imposes a limit on the extent to which urban development can grow, such as an urban growth boundary or other containment measure, the supply of land becomes fixed but, in the face of rising demand, land prices rise. Outside the boundary, where development is prohibited (or discouraged), the speculative urban use component is dampened and land value falls, perhaps to its farm use level (see
Whitelaw (1980) and Nelson (1986, 1992) for more detailed discussion). There is thus a gap in the land value gradient where land value inside the growth boundary rises and the value outside falls.

Empirically, UK geographer and planner Peter Hall observed this outcome in 1973, when he wrote that land price inflation, one effect of UK containment policy:

... has not been willed by anyone except perhaps a small body of speculators, and indeed is a source of grave embarrassment to successive governments. It is neither physical nor specifically spatial; but it is the direct result of applying spatial policies of control without understanding the consequences. It is the fact of inflation of land and property prices, at least since the late 1950s, on a scale never before witnessed in British history. This fact in turn has reacted on the behaviour of developers, who have reacted with their own form of containment, more severe in character than the plans originally intended. (Hall et al., 1973, p. 394; italics in original)

To Hall and others, no effective measures had been taken to check the rise of land prices, and the system of physical control in place actually served as a key component in the inflationary spiral (see also Self, 1982; Fulford, 1996; Johnson, 1996).

In the USA, numerous studies of Oregon’s growth management system have been conducted (see Easley (1992), Knaap & Nelson (1992), Howe (1993) and Daniels (1999) for summaries). The programme seems to be effective in limiting urban sprawl. From 1980 to 1990, for example, the Portland area’s urbanized population grew by 14%, but urbanized land expanded somewhat less, at 11%. Ehrenhalt (1997) points out that this came at the cost of higher prices for developable land. Nelson (1985) was able empirically to demonstrate this effect using the growth boundary around Salem, Oregon. He found that when a given containment programme limits the supply of urban land available for development to the amount needed to satisfy demand over a 20-year period, the urban fringe land market internalizes its supply, restricting influence within 4 years. Two later analyses of Oregon land prices both within and outside the urban growth boundaries of Salem and Portland revealed that land prices remained consistently higher within the growth boundaries than outside the boundaries (see Knaap & Nelson, 1992).

Studies of the effects of containment programmes on land prices in other areas have also been conducted. Landis (1986) found that the urban containment programmes of three California cities (Fresno, Sacramento and San José) led to higher land prices. Schwartz et al. (1979) studied Petaluma, California, a community that sharply restricted growth through limits on new building permits. They found that the growth limitation led to higher housing prices than occurred in a comparison city that did not employ growth controls. Those studies suggest that containment may put pressure on land markets to accommodate the demand for urban land uses by developing in hazardous landscapes.

**Urban Containment and Exposure to Hazards**

If developers are experiencing rising prices for land of the type they traditionally acquire for development, in order to maintain profitability they must raise
housing prices, use land more efficiently by building at higher densities or acquire lower-priced (i.e. marginal and hazardous) land that otherwise meets their criteria for access, amenities and public services. Two of these adjustments—raising housing prices and increasing density through smaller lot sizes and multi-storey construction—have been documented through systematic empirical research (Nelson, 2000). The third—increased development of hazardous land—has previously not been dealt with in research on urban containment, but circumstantial evidence presented later in this paper suggests that it too is a likely consequence of containment programmes. In addition, public infrastructure serving new development in hazardous areas is also put at risk, and its failure in disasters can complicate emergency evacuation and disaster response operations, such as fire fighting (e.g. see Burby et al., 1991).

Higher housing prices in response to urban containment are likely but not necessarily inevitable. If local governments allow the limited supply of land to be developed more intensely, housing prices may not rise even though lot sizes may fall. Even if land use is allowed to become denser, however, it is still possible that housing prices may rise even if housing production meets demand. This occurs if the resulting urban form generates benefits to households they did not have before, such as more options to get around, reduced reliance on cars, more job opportunities that are accessible, higher-quality services, more amenities and so forth. Land economic theory requires that benefits accruing to households should be capitalized into the land and, ultimately, into the house (see Nelson (1999, 2000) for further elaboration). Researchers, in fact, have found that housing prices have risen after the initiation of containment programmes when local regulations are not also adjusted to increase development density appreciably (e.g. see Landis, 1986).

Higher density has been observed by Howe (1993) as a way that developers tend to use to compensate for higher land costs. This was possible in Oregon because compliance with state goals for affordable housing required cities to expand the amount of land zoned for multi-family housing and to increase the allowable density for single-family zones. Miller (1986) found this in Boulder, Colorado, as well. Nelson (1999, 2000) compared housing densities in Portland, with its growth boundary, with those in Atlanta, where urban sprawl is rampant. He found that in Portland average lot sizes are one-quarter the size of those in Atlanta, which provides additional evidence that developers respond to rising land prices by using land more efficiently. Finally, research in Australia, where state governments have pursued urban containment policies, indicates that developers have responded there by also building at higher densities. For example, average lot sizes in the Sydney metropolitan area dropped from about 700 m² to 550 m² after the initiation of urban containment policies (see Troy, 1996).

Developer adjustments through higher density, however, have not always been allowed. In cities where resident opposition led city governments to restrict zoning for multi-family housing, the expected density adjustment did not materialize, as Johnston et al. (1984) demonstrated in a study of Sacramento, California. A similar effect has been recorded in Sarasota, Florida, where a growth boundary was enacted, but the county did not follow through with higher density zoning within the growth boundary (see Easley, 1992).

Systematic empirical evidence, similar to that developed for housing price and density as adjustments to containment, is not available for adjustment through
the development of lower-priced sites subject to natural hazards. Two types of circumstantial evidence, however, suggest that this adjustment can also result from urban containment. The first comes from an examination of the vulnerability to disasters of places that have natural, physical barriers that have constrained urban expansion. The second comes from reports of natural disasters and vulnerability to disasters in places that have pursued containment through regulatory growth boundaries and other means.

Three urban areas, New Orleans, Los Angeles and San Francisco, illustrate the connection between the natural containment of urban expansion and exposure to hazards. New Orleans, bounded by the Mississippi River, Lake Pontchartrain and extensive coastal marshes, is one of the most contained urban areas in the USA. Its centuries-old vulnerability to flood and hurricane disasters is legendary. The New Orleans metropolitan area experienced over US$4 billion (1990 dollars) in losses from Hurricane Betsy in 1965, but even heavy rainstorms can cause extensive damage. The most recent example of this occurred in May 1995, when rainfall overwhelmed the storm drainage system and flooded more than 35,000 homes. Vulnerability to a major natural disaster in New Orleans, however, is much greater. In spite of a flood protection system that includes over 520 miles of levees, 270 floodgates, 92 pumping stations and hundreds of miles of drainage canals, in a severe, category 5 hurricane New Orleans could experience over US$30 billion in property damages and massive loss of life (Pielke & Landsea, 1997).

The San Francisco Bay area offers another example of a naturally contained urban area with extreme vulnerability to natural hazards. The city of San Francisco is surrounded by water on three sides and hills on the fourth. In 1906 a magnitude 8.25 (Richter scale) earthquake shook the city for 40 seconds, followed 13 minutes later by a powerful aftershock. The earthquake triggered a fire that burned an area of 490 blocks (Bronson, 1986). The fire and earthquake together resulted in 500 deaths, destroyed the entire business district and left three-fifths of the city’s inhabitants homeless (Platt, 1998). After the earthquake, observers noted that the damage from ground shaking was highest on unconsolidated soils and warned against further building on fill adjacent to San Francisco Bay (Tyler, 1906). Ironically, 83 years later some of the worst damage in the Loma Prieta earthquake in 1989 occurred in the city’s Marina District, which was constructed on rubble dumped into San Francisco Bay after the 1906 earthquake to provide additional building sites.

Two years after the 1989 earthquake and across San Francisco Bay in Oakland, a city where urban growth is similarly constrained by topography, extensive hillside development resulted in disaster in 1991 when a small brush fire rapidly expanded to create an urban firestorm. About 790 houses burned in the first hour as the fire moved easily from house to house up the hillsides. By the time the fire was brought under control, it had destroyed over 3300 homes and resulted in 25 deaths. Like San Francisco before it, in the fire’s aftermath Oakland did little to correct the pattern of development that contributed to the firestorm. In fact, according to Platt (1998, p. 51), “The pattern of rebuilding, while safer in certain details, is more dense and congested than before and raises the prospect of another catastrophe”.

To the south, physical barriers have contained the growth of Los Angeles to the corridor between the Pacific Ocean to the west and mountains to the east. As a result, density in Los Angeles is among the highest in the USA, and the area’s
exposure to a variety of natural hazards is well known. Mike Davis recently brought this to light in his book *Ecology of Fear: Los Angeles and the Imagination of Disaster* (Davis, 1998). Davis (1998, p. 7) writes: “The destructive February 1992, January 1993, and January 1995 floods ($500 million in damage) were mere brackets around the ... October–November 1993 firestorms ($1 billion) and the January 1994 earthquake ($42 billion)”. This vulnerability to natural hazards, he argues, stems from “generations [of] market-driven urbanization [that] has transgressed environmental common sense ... [as] historic wildfire corridors have been turned into view-lot suburbs, wetland liquefaction zones into marinas, and floodplains into industrial districts and housing tracts” (p. 9).

The hazards and vulnerability of places whose growth has been constrained by physical barriers to peripheral expansion are widely recognized, but there is evidence that places where growth is constrained by public policy are also highly vulnerable to natural disasters. Portland, Oregon, Sacramento, California, and Boulder, Colorado, exemplify this in the USA, while examples outside the USA include areas as diverse as Taipei, London and Sydney.

In the USA there is the following evidence.

- Portland, Oregon, experienced severe flooding in 1996 and 1997. Flood losses were heaviest in areas where run-off was exacerbated by increased impervious surfaces and inadequate storm drainage systems. According to Portland Metro’s senior planner for water resources, the 1996 flood revealed:

  There needs to be more of a connection between natural systems and how we build. We haven’t taken natural systems into consideration in the built environment. (Quoted in Mazza, 1996, p. 2)

- Sacramento, California, another city with a long-standing growth boundary, has 300,000 people and US$9.2 billion in property at risk from a flood on the Sacramento River, which has flood protection levees that can be overtopped by a fairly modest ‘50-year flood’ (*Sacramento Business Journal*, 1998).

- Boulder, Colorado, our third US example, enacted curbs on peripheral expansion in the 1960s. The potential for damage from flooding in Boulder is substantial, since urban development subsequently intensified in the Boulder Creek floodplain (Mileti, 1999).

Outside the USA, the potential for natural disasters has also increased in areas that have adopted containment policies.

- Taipei, Taiwan. The earthquake in Taiwan on 20 September 1999, which resulted in the deaths of 2000 people, provides the most recent evidence linking urban containment policy and exposure to hazards. In this case, Sims (1999) reports that a primary cause of the high death toll was the large number of high-rise apartment buildings sited without consideration to the proximity of known earthquake faults within Taiwan’s densely populated cities. The high-rise apartments were built in response to an urban development policy that encouraged compact development. Indeed, as early as 1979, an official of the Land Reform Training Institute of Taiwan remarked: “The land policy, while directed toward the preservation of farmland, has had the definite effect of creating compact cities” (Woodruff, 1979, p. 313).

- London, UK. In London, the so-called ‘western corridor’ of development along the Thames valley has witnessed some of the most rapid rates of urban
growth in England since a green belt was established in the late 1940s. Here, the growth of a series of urban centres, including Staines, Datchet, Windsor and Maidenhead, has been constrained by tightly drawn green belt boundaries, with the consequence that infill residential development of increasing densities has been the principal means of accommodating the rising number of households. Research by Parker (1995) (see also Parker, 1999), which traces land use and property numbers over time, reveals that the density of development on floodplains within these towns has greatly increased, causing flood damage potential to rise between 1950 and 1995 by well over an order of magnitude in real terms (i.e. by more than 10 times).

- Sydney, Australia. Sydney offers another case of increasing pressure on flood hazard areas brought about by urban containment policy. Sydney’s early planners tried to constrain growth through UK-style green belts as set out in the 1948 County of Cumberland Planning Scheme. However, fuelled by massive post-war immigration and rising affluence, the green belt was ignored by both private and government developers (Spearritt & DeMarco, 1988). With an adequate supply of inexpensive land available for development on the periphery, identified hazardous areas could be avoided easily (Handmer, 1999). This situation began to change when urban consolidation was introduced by the Sydney Region Outline Plan, 1970–2000 and its subsequent updates and associated policies, which provide incentives to infill already developed areas to higher densities (New South Wales Department of Housing, 1991; Ryan, 1991; Pearson, 1994). The consolidation policy and high land values together have contributed to a substantial increase in floodplain occupancy, which state government policy has allowed to flourish under a policy of leaving decisions about floodplain planning and regulation to local government discretion (see May et al., 1996).

The evidence of exposure to natural disasters in the USA and elsewhere after the adoption of urban containment policies, of course, is circumstantial, since we are not able to control for a number of other factors that can contribute to exposure to hazards. We believe it is sufficient, however, to suggest that additional research is needed to examine this issue. We also believe it argues for greater attention to hazard mitigation by planners in areas where containment policies have been adopted or are proposed.

**Combining Containment with Hazard Mitigation**

The threat of greater exposure to natural hazards can be minimized if, at the same time that containment programmes are put in place, planners prepare a comprehensive hazard mitigation plan that evaluates potential vulnerability to a variety of natural hazards and identifies ways to develop safely within urban growth boundaries. Because hazard mitigation also entails public costs, this will help ensure that planners who propose or undertake containment programmes do so with a better understanding of the full costs, as well as benefits, of containment.

To cope successfully with the potential for increased vulnerability, planners can choose hazard mitigation measures from among six sets of options (see Burby (1998) and Schwab et al. (1998) for a fuller discussion of these policy choices).
(1) Preventive policies and actions are designed to limit the exposure of new development to losses from hazards. These measures include: enhanced building code and infrastructure design standards to enable buildings, roads and bridges, and lifelines such as water and sewerage systems, to withstand the forces exerted by hazards; zoning to reduce or cluster development densities within hazardous areas; and public acquisition of land or protective easements in hazardous areas to preclude their development.

(2) Property protection policies and actions limit the exposure of development to hazards on a parcel by parcel, infrastructure element by element basis. They are required to deal with the pre-existing exposure of property and infrastructure to hazards, but they also acknowledge the fact that compact development can increase the severity of some hazards, such as increased flood frequency as impervious areas increase within watersheds. These policies include public assistance to building owners to enable them to retrofit structures to comply with more stringent building standards, the relocation of structures from hazardous to less hazardous sites, the acquisition and clearance of buildings located in hazardous areas, assistance in obtaining insurance against losses and reconstruction of infrastructure to increase its resilience to hazards.

(3) Structural protection policies and actions limit the exposure of development to hazards (principally flooding) on an area-wide basis. These policies and actions include requirements that developers should take steps to limit post-development increases in storm water run-off and public investment in flood control dams, levees and channel improvements.

(4) Emergency service policies and actions lessen the impact of a hazard after its onset. They include warning, evacuation, flood fighting, fire fighting and emergency sheltering actions. To the extent that urban containment policies increase vulnerability, it is likely that emergency services will need to be upgraded to deal with the added threat to public safety.

(5) Natural resource protection policies and actions preserve and restore natural areas that also help lessen the magnitude of hazards. These measures include wetland protection through acquisition or regulation, erosion and sedimentation control and shoreline protection.

(6) Public information policies and actions build awareness of hazards and knowledge of actions that households and businesses can adopt to mitigate them. Examples include the publication of maps that delineate hazardous areas, the acquisition of library materials on natural hazards and hazard mitigation and technical assistance to property owners to enable them to make informed choices between various hazard mitigation options.

Effective hazard mitigation programmes usually include measures from among each of these options, since vulnerability is multi-faceted. For example, neither structural nor property protection measures provide complete protection, since hazards more severe than these measures were designed to cope with can occur, with catastrophic results. Thus, emergency services are always needed. Preventive measures and natural resource protection are expensive, in terms of both land acquisition costs and development opportunities foregone; as a result, they usually cannot be applied to all land that is vulnerable to hazards, so they are used in combination with other hazard mitigation techniques. With careful
planning, planners can identify the right combination of techniques for a particular urban area.

Natural disasters and vulnerability to disasters in areas with natural and policy-driven urban containment provide evidence that urban planners have paid too little attention to hazard mitigation. Studies of the hazard mitigation provisions of comprehensive plans indicate that without explicit state mandates to prepare plans, few localities address hazards and mitigation in their planning (e.g. see Berke et al., 1996; Burby et al., 1997b). In fact, even when they are mandated to address hazards, plans can be extremely weak, as Deyle & Smith (1998) demonstrated in their study of the hazard mitigation aspects of comprehensive plans in Florida, and as Burby et al. (1997b) found was the case with the state-mandated safety elements of general plans in California. Thus, while hazard mitigation plans and programmes have the potential to counter the adverse effects of containment policy on vulnerability to disasters, without recognition of this potential by planners at both the state and local levels, little attention to mitigation is likely to be forthcoming.

Conclusions

In this paper, we have provided a theoretical argument and evidence from several cases to suggest that urban containment programmes can contribute to the exposure of people and property to natural hazards. If planners fail to recognize this possibility, they can inadvertently contribute to losses of property and lives in natural disasters. Avoiding this situation requires careful attention to hazard mitigation in planning compact urban communities, but the evidence to date suggests that this has yet to occur.

This does not mean that urban containment is bad public policy. The trade-offs, when measured in savings on infrastructure costs, reductions in environmental damage, enhanced sense of place, more efficient economic interactions and greater proximity to activities and other areas of interest, may weigh in favour of urban containment despite the added vulnerability from natural hazards. It is important, however, to measure the added exposure and calculate the costs of mitigation so that the trade-off can be assessed.

In this regard, we believe that in evaluating whether to impose containment policies or not, planners need to take care to give due consideration to hazards by preparing, concomitantly, hazard mitigation plans. These plans should consider how containment will affect development pressures in hazardous areas, identify a range of measures for coping with increased vulnerability and determine the costs of these measures and the institutional capacity to carry out a comprehensive hazard mitigation programme.

Finally, although we think it unlikely, it is certainly not entirely out of the question that areas pursuing urban containment could already be more protective of hazardous landscapes than comparable areas. For one thing, because urban containment requires considerable political skill backed by public support, those same skills and support may lead to more protection of hazardous areas. In the light of this, we believe that additional systematic empirical research is needed to verify the effects that urban containment policy has on exposure to natural hazards and to determine the degree to which containment has been accompanied by attention to hazard mitigation. In particular, we believe two research questions require answers.
• Does urban containment increase the development of hazardous landscapes, such as floodplains and steep slopes, relative to a control situation without containment policies? We suspect that given two areas that are roughly comparable, the area affected by urban containment will see more development of hazardous landscapes than the area not contained.

• To what degree have areas pursuing urban containment adopted appropriate hazard mitigation plans and other counter-measures to reduce the vulnerability of urban development and public infrastructure to damage from natural hazards? In this case, we believe there will be little difference in the attention given to hazard mitigation by areas with and without urban containment programmes, given the low political salience of hazards in local planning (e.g. see Rossi et al., 1982; Burby & May, 1998).

The information provided by answers to these questions can be used to decide whether, in fact, additional actions are needed to counter the potential for containment policy to increase vulnerability to hazards.

If our hypotheses are supported by systematic empirical research, then several adjustments in containment policy could be needed. In particular, we believe that states such as Maryland, New Jersey, Oregon and Washington, which mandate or encourage urban containment, must take equally vigorous steps to mandate hazard mitigation planning and to provide technical and financial assistance to make such planning effective. We also believe it is incumbent on local planners who advocate urban containment policies to at the same time give appropriate attention to plans and policies to ensure that vulnerability to natural hazards is kept in check. If these actions are taken, then we believe that the benefits of containment can be realized without also incurring the monetary costs and human suffering that accompany natural disasters.

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