Environmental Impacts of Illegal Immigration on the Cleveland National Forest in California*

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Since the inception of Operation Gatekeeper along the U.S.-Mexico border, there has been an increase in environmental impacts on the Cleveland National Forest, in eastern San Diego County, California. This is almost certainly due to an increase in the number of undocumented immigrants using the area as a gateway to the interior of the United States. In this research, we use the tools of geographic information systems (GIS) to measure the scope and extent of this impact, focusing on the creation of illegal trails and the impact of illegal campsites and campfires on the environment of the Descanso Ranger District within the national forest. Our findings suggest that between the start of Operation Gatekeeper in late 1994 and the end of the study period in 1999, there were 772 meters of new trail created per 1,000 unauthorized immigrants, accompanied by 656 square meters of area disturbed per 1,000 immigrants, fifty kilograms of litter left behind per 1,000 immigrants, eleven illegal campfires per 1,000 immigrants, and 1.7 hectares burned by wildfires attributed to illegal immigrants. **Key Words: California, environmental impacts, GIS, illegal immigration, migration.**

Introduction

Over the past decade, policy-makers and researchers have shown a growing interest in the relationship between human migration and the environment. Traditionally, environmental impacts of migration have occurred within national boundaries. Until recently, the international dimension of this relationship has been largely overlooked. With the pace of globalization accelerating, however, the international dimension is increasing in scale and importance (Hugo 1996). Participants in the 1996 "International Symposium on Environmentally Induced Population Displacements and Environmental Impacts Resulting from Mass Migrations" in Switzerland discussed four categories of negative migration-driven environmental impacts: (1) those that directly damage ecosystems, primarily affecting forests and fresh water resources; (2) those that indirectly affect local markets and prices and cause game-park barrier destruction; (3) those that indirectly affect environmental health conditions, including water supply and air quality; and (4) political impacts, such as strife between local residents and temporary camp dwellers, where competition for natural resources can act as a pretext for refugees to ignore local resource management practices and regulations.

In the county of San Diego, California, the impact from migratory movement is being felt on a daily basis. Unauthorized or illegal immigration from Mexico has long been a hotly debated issue along the U.S.-Mexico border. Historically, the San Diego area has been one of the most popular places to cross illegally. This westernmost segment of the U.S.-Mexico border was the site of 45 percent of all illegal immigrant apprehensions in 1993 alone (Cornelius and Kuwahara 1998). In response to this problem, the United States Border Patrol unveiled Operation Gatekeeper in October 1994. Gatekeeper—a result of legislative efforts originally sponsored by San Diego congressman Duncan Hunter—is part of a $540 million immigration initiative that seeks to deter illegal immigrants from entering the country by physically preventing them from crossing the border by building a fence and hiring more law enforcement agents to patrol the U.S. side of the border (Becks 1997). Funding for this project was enhanced by the 1996 amendments to the Immigration and Nationality Act (INA), embodied in the Illegal Immigration Reform and Immigrant Responsibility Act (P.L. 104–208) (U.S. Immigration and Naturalization Service 2002).

The success of Operation Gatekeeper in deterring illegal immigration in San Diego is a

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matter of some debate. Gatekeeper followed on the heels of a similar operation in El Paso, Texas, but the effort has been compared to placing a bandage on a gaping wound (Perryman 1995). Border Patrol apprehensions have since declined in the San Diego sector, but increased in Arizona (Martin 2000a), suggesting a displacement but not a reduction in the flow of undocumented immigrants across the border. Plenty of evidence exists worldwide that host governments will have great difficulty stopping an influx of immigrants just by militarizing their frontiers (International Organization for Migration 1996). Surveys of Mexican migrants by Donato and colleagues (1992) reveal that they will simply keep trying to cross the border until they succeed. Regardless of how many times they are apprehended, almost every migrant who truly wants to enter the United States eventually gets in (Donato, Durand, and Massey 1992).

Nonetheless, based upon apprehension data supplied by the Immigration and Naturalization Service (1998), it appears that Operation Gatekeeper has pushed illegal immigrant traffic out of the traditional crossing routes near Imperial Beach and San Ysidro and into the eastern, more rural portions of San Diego County. Imperial Beach, the westernmost Border Patrol station in San Diego County, had previously been the site of over 25 percent of all apprehensions in San Diego County. This rate began to fall in 1995, after the start of Operation Gatekeeper in October 1994, and has been under 10 percent since then. Campo, the easternmost station in San Diego County, had annually been the site of less than two percent of all apprehensions in the County. This number began to rise after 1995, with Campo's apprehension rate exceeding 16 percent in the following three years.

This shift in migration patterns has exerted an unexpected impact on the natural environment. In the Cleveland National Forest, to the east of San Diego, as many as 100 illegal immigrants per day are estimated to pass through the Descanso Ranger District, including the Hauser and Pine Creek National Wilderness Areas. Hundreds of trails have been created in hillsides and thousands of illegal campfires have been left unattended by undocumented migrants since the inception of Operation Gatekeeper. Meadows and sensitive plants have been trampled and surface-water quality may have been significantly damaged by human waste (U.S. Forest Service 1998a; Pasek 1999). Although we cannot definitively prove that immigrants have caused this impact, the circumstantial and anecdotal evidence is compelling. The timing of the impact is consistent with this hypothesis, since the observed environmental degradation began shortly after Operation Gatekeeper was put into place. Furthermore, the number of arrests of illegal immigrants has increased, and much of the trash left behind in illegal campsites appears to have originated in Mexico, according to employees of the U.S. Forest Service (Ron Woychak, Resource Manager for the Descanso Ranger District of the Cleveland National Forest, notes by first author from interview, 1998).

The environmental impact that can result from immigration is potentially severe and multifaceted. Refugee movement into a spatially restricted area already vulnerable to environmental degradation can be devastating (Hugo 1996), and also long-lasting (Bloesch 1996). The unprecedented number of people in the world who are refugees or otherwise displaced (over 50 million; International Organization for Migration 1996) has culminated in the need to measure the environmental impacts of illegal immigration on natural resources.

The purpose of this study is to measure the environmental impacts of illegal immigration on the natural resources of the Descanso Ranger District in the Cleveland National Forest in southern California. State parks and national forests along the U.S.-Mexico border face unique challenges unheard of in other parts of the country. The squeezing of immigration in their direction has made them a natural route for immigrants attempting to make their way undetected across the border. Using geographic information system (GIS) methods, we located and measured the road and trail network that had been created in the Cleveland National Forest, presumably by illegal immigrants as well as by law enforcement personnel, since the inception of Operation Gatekeeper. We then compared this road and trail network to the network that existed prior to the start of Operation Gatekeeper. We also made use of data that have been compiled by the U.S. Forest Service on immigrant apprehensions and

counts of illegal campfires, litter collected, and wildfires in the area.

Background

Despite growing interest on the effects of migration, knowledge of the environmental impacts resulting from migration remains limited. The analysis that has been performed tends to be rudimentary, although work has been done to develop frameworks for analyzing alternative policies as they relate to the sustainable use of forest trees in the presence of refugees in Malawi (Babu and Hassan 1995). Few studies have investigated the medium- and long-term impacts of international migration. In particular, there has been little investigation to discover the long-term significance of these relatively short-term effects, the extent to which ecosystems can rebound from impacts due to mass migrations, and the factors that enhance environmental recovery (Hansch and Jacobsen 1996).

Congressional briefing papers prepared by the U.S. Forest Service (1996) have discussed the impact of illegal campfires left behind by undocumented migrants. These fires are often built in wilderness areas that have not recently experienced a significant wildfire. They have been likened to "ticking time bombs," because wildfires in these generally arid areas can spread quickly, destroying homes and property worth millions of dollars (U.S. Forest Service 1996). Information provided by the U.S. Forest Service (1998b) indicates there were over 800 illegal campfires in the Cleveland National Forest in 1996 and over 1,300 in 1997. These campfires led to forty wildfires in 1996 that resulted in over 400 hectares of Forest Service land being burned (U.S. Forest Service 1997).

Bloesch (1996) and Hansch and Jacobsen (1996) also discuss another impact, soil erosion. It often results directly from vegetation destruction and deforestation. In Mozambique, Malawi, Zimbabwe, Zambia, and Ethiopia, international refugees and internally displaced groups are forced by their desperate situation to remove trees for energy and shelter. This deforestation has had increased impact on soil erosion and has produced an almost moonscape-like environment in these areas (Singh 1996). In Haiti, 50 percent of the country is reported to have been affected by increased erosion, with eroded soil accumulating in the streets of Port-au-Prince, where it must be removed by bulldozers. This erosion is the direct result of deforestation by internally displaced people using the forest resources for fuel and building material (Claussen 1994). Soil erosion has also been cited as a problem resulting from the increased number of trails that have developed in the Cleveland National Forest as a result of immigration traffic (U.S. Forest Service 1998c).

The activities of the Border Patrol and other immigration enforcement agencies comprise another indirect impact of international migration. Border Patrol vehicles have expanded previously existing roads and reopened old roads that Forest Service personnel intended to be taken out of use and thus reclaimed by vegetation (Woychak, interview, 1998; Edward Heinrich, fire prevention specialist with the U.S. Forest Service, notes by first author from interview, 1999). Border Patrol agents operate sport utility vehicles (SUVs) that contribute to erosion and cause other environmental impacts similar to ones discussed in studies of off-highway vehicle (OHV) impacts to the environment (Fridell 1990; Pudoff 1992).

The third category of impact is the deterioration of environmental health conditions involving sanitation issues, damage to the water supply, accumulation of litter and human waste, and personal safety. Waterways in the Descanso Ranger District were the subject of water quality testing in 1997 by the City of San Diego, which operates two reservoirs in the area. Most of the testing showed no consistent change from upstream to downstream; however, the results from a site along Cottonwood Creek in Hauser Canyon showed consistent changes (Jeff Pasek, head biologist for the City of San Diego's Water Department, notes by first author from interview, 1999). Over 11,000 kilograms of litter—including human waste—were retrieved from the Descanso Ranger District in 1997 alone (U.S. Forest Service 1998b). Wood is a common source of fuel for refugee populations throughout the world. Smoke from wood burning for cooking and heating is documented as a health risk to the upper respiratory tract (International Organization for Migration 1996). In addition, in general, when displaced and refugee people have to walk long distances to gather wood for fuel, they risk acts

of physical violence, including rape (International Organization for Migration).

In the first four years after the start of Operation Gatekeeper, 130 illegal immigrants died in San Diego County (Ector Benegas, Mexican Consul, San Diego, personal communication via email to first author, 1999). Most deaths are to males, and usually their deaths are attributed to dehydration or hypothermia; however, others have died in motor vehicle accidents or by drowning. This phenomenon is not limited to San Diego County. In 1998 there were seventy-eight deaths reported by the El Centro Border Patrol Station (U.S. Border Patrol 1998). Other deaths may have occurred among illegal immigrants who were able to return to Mexico before dying or were just never found. Deaths by dehydration, hypothermia, and drowning illustrate the dangers immigrants now face when attempting to cross the border in the rugged mountains of eastern San Diego county. Several incidents occurring in the Descanso Ranger District, where illegal immigrants have either died or had to be rescued from exposure to inclement weather, illustrate the danger to personal safety (Sanchez 1998). In 1996, 22 illegal immigrants died from exposure, 19 died in 1997 (U.S. Forest Service 1998c) and 6 died in one week in 1999 (Fox 1999). In March 1999, a San Diego–area Border Patrol agent and three illegal immigrants he was transporting were killed when the agent's vehicle rolled down a steep cliff during heavy fog (Portillo 1999). This accident took place just a few miles west of the Descanso Ranger District.

The final category of impact is strife between local residents and immigrants. Homer-Dixon (1996) studied the relationship between environmental scarcities and violent conflicts. He notes that scarcities of certain environmental resources, such as agricultural land, clean water, and forest resources, are contributing to mass violence all over the world. In addition, these scarcities have contributed to fierce competition and violence among ethnic groups in areas where shortages and distribution inequities have forced rival groups to live together (Homer-Dixon 1996). In the Cleveland National Forest, residents have complained about heavy traffic and intrusion by illegal immigrants, citing break-ins and thefts (U.S. Forest Service 1996).

There have also been confrontations between U.S. residents and the Border Patrol in the backcountry east of the City of San Diego. Residents in the sparsely populated Mountain Empire region east of San Diego have filed suits against the Border Patrol in order to limit their activities. The suits are based upon claims that the Border Patrol is interfering with residents going about their daily lives; specifically, residents have complained of frequent stops and searches. The Immigration and Naturalization Service (INS) counters that some residents are engaged in illegal activities and notes that forty-six area residents have been arrested for trafficking drugs and eight for smuggling illegal immigrants (Martin 2000a, 2000b).

Environmental impacts identified as resulting from international migration are similar in many ways to environmental impacts associated with recreational forest use (hiking and camping) and its management. Recreational use of wilderness has been cited as affecting both physical and biological resources (Hammitt and Cole 1987; Kuss, Graefe, and Vaske 1990). Littering and deterioration of trails and campsites are among the most commonly reported impacts. Undesired trails tend to develop along frequently used cross-country routes and in popular destination areas. Campsites proliferate in destination areas where use is not limited to a relatively small number of campsites. Wilderness rangers are forced to spend a large proportion of their time picking up litter. Human waste is also a problem when use is relatively high (Cole, Lucas, and Petersen 1987).

Aquatic systems are affected by increasing turbidity and sedimentation loads from erosion along trails and other denuded areas. Human waste pollutes waterways. Concentrated recreation use along trails and campsites affects soils and vegetation. Soils are altered physically, biologically, and chemically by impacts associated with recreation. Vegetation abundance and community composition are changed when plants are killed or damaged. Animals are impacted when their habitat is disturbed or are approached too closely by recreational visitors (Cole 1994).

A study by Mortensen (1989) noted the impact of recreation use on trails, including increases in trail width, exposure of mineral soil and soil compaction, loss of duff, and campsite

development. Bayfield (1973) analyzed the impact of newly created and unmanaged Scottish hillpaths, demonstrating the patterns of deterioration and the lateral spread of people (walkers) across and away from the hillpaths. He observed that the width of unmanaged footpaths increased with the wetness, roughness, and steepness of the path surface and that walkers took the most convenient route in terms of surface and direction.

Research has been conducted on ecological changes in campsites in designated wilderness areas and the extent to which these changes become more pronounced as use increases (Cole 1983, 1988). A significant correlation has been found between the amount of use and the change in (or loss of) vegetation cover, seedlings, and the exposure of mineral soil. The impact of canoeists on newly developed campsites has also been studied (Merriam and Smith 1974). Much work has gone into designing an impact monitoring system (Cole 1994; Cole et al. 1997) as well as modeling wilderness campsites to determine factors that influence the degree of impact (Cole 1992).

Studies of impacts to trails and campsites from recreational usage show that much of the damage is inflicted after only a few visits or passes through an area and that the spatial distribution tends to be fairly static (Mortensen 1989; Cole 1994). Impacts from illegal immigrants are different in that illegal immigrants are constantly in flight from capture during their passage through the forest. As existing trails and campsites are identified and patrolled by law enforcement agents, illegal immigrants establish new trails and campsites in an effort to escape. This creates a cat and mouse game in which immigrants recycle old trails while simultaneously establishing new trails and campsites.

Data and Methods

Description of the Study Area

This study was conducted in the southern portion of the Descanso Ranger District in the Cleveland National Forest, located in San Diego County, California (Figure 1). The area contains a variety of vegetation communities, including coastal sage scrub, chaparral, broadleaf woodland, conifer forest, grassland, and riparian habitat. This area was selected because of its proximity to Mexico, which is experiencing large northward migratory movement. The presence of Interstate 8, a major transportation artery bisecting the Descanso Ranger District some twenty-four to thirty-two kilometers north of the border, has made the area a natural avenue for illegal immigration since the inception of Operation Gatekeeper. Access to the forest is provided by a combination of interstate, state, county, and interior roads, approximately half of which are under Forest Service jurisdiction (U.S. Forest Service 1986).

Data Collection

The study was conducted by integrating several sources of data into a geographic information system, using ESRI ArcInfo software. Data layers included (1) road and trails, (2) litter, (3) number of campfires, (4) area burned by fires, and (5) immigrant data. Data on roads and trails were collected using three methods. First, the locations of roads and trails in existence prior to Operation Gatekeeper were obtained from the U.S. Forest Service in digital format. The trails were divided into two classifications, maintained trails and unmaintained trails. Maintained trails are trails within the Cleveland National Forest maintained by Forest Service personnel on a regular basis—e.g., the Pacific Crest Trail. Unmaintained trails, hereafter known as social trails, are trails that are present within the forest and acknowledged by the Forest Service to exist but that were not created nor maintained by Forest Service personnel (Tom White, member of the U.S. Forest Service in the Cleveland National Forest, notes by first author from interview, 1999).

Next, the locations of roads, trails, and campsites created in the Hauser subarea as a result of illegal immigration were recorded through field measurement. The roads, trails, and campsites in the Hauser subarea were mapped using a portable global positioning system (GPS). Road and trail width was measured by stretching a tape measure perpendicular to the road or trail. As each road or trail was traversed, all places obviously disturbed by camping were located. Each camping site was mapped as a point feature using the GPS. Camping sites were easily recognizable by the large amount of litter present, including discarded food wrappers, empty water bottles, and clothes, and by disturbance to the ground cover and the presence of fire scars. Finally, the locations of pioneered trails created by illegal

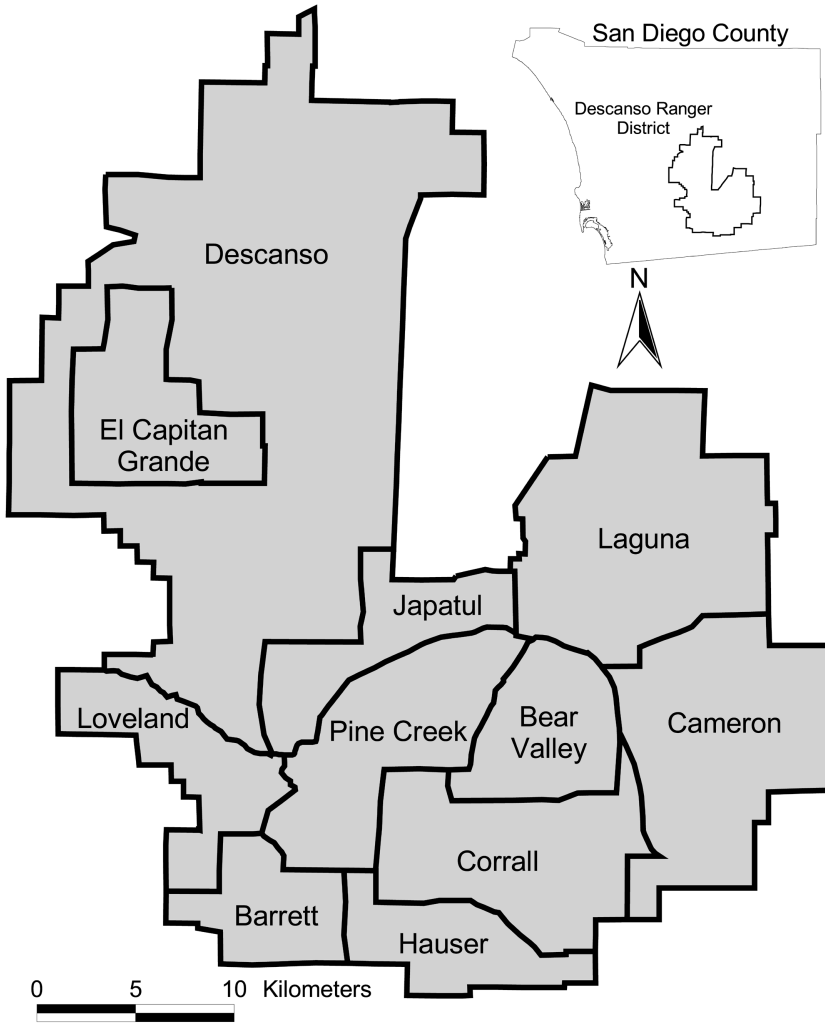

Figure 1 *Study site: subareas of the Descanso Ranger District.*

immigrants in the other forest subareas were determined using Forest Service field maps and information provided during informal interviews with Forest Service field personnel.

Within the GIS, the Descanso Ranger District was divided into a series of subareas using a method similar to one utilized by the U.S. Forest Service. Methods were developed to rapidly quantify the spatial extent and degree of impact caused by immigration. The network of maintained and social trails that existed prior to the inception of Operation Gatekeeper was combined. The coverages containing trails created as a result of illegal immigration since the start of Operation Gatekeeper were also combined, so that all pioneered trails were together in the same coverage. Arc Macro Language (AML) programs were written to compute the length of pre-and post-Operation Gatekeeper trails and roads in each forest subarea. The number of trail intersections (nodes) in each subarea before and after the inception of Operation Gatekeeper was computed using the same programs. The coverage of maintained and social trails

from before Operation Gatekeeper was clipped to each separate forest subarea and a point or node coverage of trail intersections was created. Next, the coverage of pioneered trails from after the start of Operation Gatekeeper was appended with the coverage of maintained and social trails from before Operation Gatekeeper. This coverage was also clipped to the forest subarea and a point or node coverage of trail intersections was created. These coverages were appended together to create a point or node coverage of trail intersections for both periods. The density of the trail network was evaluated in terms of the number of intersections represented by nodes in the trail coverages.

Data on other categories of impact—including the amount of litter, number of illegal campfires, number of illegal wildfires, and hectares burned by wildfires—were obtained through informal interviews with Forest Service personnel and local government officials and by reviewing of historical documentation, and were recorded in either a weekly incident report or monthly summary. Data concerning number of immigrant apprehensions and immigrant deaths were obtained through informal interviews with federal law enforcement personnel as well as from historical records.

Data Analysis

Our analysis focused on the calculation of the environmental impact per immigrant, as a way of producing a more generalizable assessment of what it means for unauthorized immigrants to be traversing a relatively fragile ecosystem. First we calculated each factor of disturbance that is presumably due to the impact of illegal immigrants: (1) how many meters of new trail were added, (2) how many new trail intersections (or nodes) were created, (3) how much ground cover was disturbed on an annual basis, (4) the amount of litter left behind by the migrants, (5) the number of illegal campfires attributed to the migrants, and (6) the hectares burned by wildfires attributed to the migrants. Next we estimated the number of unauthorized immigrants traversing the study area for each year under study, based on multipliers applied to apprehension data, as developed by Espenshade and Acevedo (1995). For these estimates, we created a range of high, medium, and low, reflecting the uncertainty about the exact number of immigrants. Then, using our estimates of the annual volume of migration through the area, we were able to estimate the annual pattern of disturbance for each factor. Finally, we calculated the per-immigrant affect of each type of environmental impact.

Results

Estimates of Environmental Impact

Overall, our estimates in Table 1 show that 240,165 meters of trail were added to the Descanso Ranger District between the inception of Operation Gatekeeper in late 1994 and the end

Table 1 *Change in Trails and Roads by Subarea, 1996–1999*

	Trails			Roads		
Subarea	**Length in Meters Before Start of Operation Gatekeeper (1994)**	**Length Measured in 1999**	**Change 1994 to 1999**	**Length in Meters Before Start of Operation Gatekeeper (1994)**	**Length Measured in 1999**	**Change 1994 to 1999**
Loveland	13,412	18,457	5,045	41,594	41,594	0
Japatul	6,625	22,030	15,405	28,731	28,731	0
Pine Creek	46,805	103,112	56,307	43,233	43,233	0
Barrett	1,734	21,805	20,071	29,580	29,580	0
Hauser	10,100	35,454	25,354	36,332	37,367	1,035
Corral	16,323	41,217	24,894	81,120	81,120	0
Bear Valley	2,091	28,963	26,872	51,578	51,578	0
Laguna	88,048	102,537	14,489	141,896	141,896	0
Cameron	21,818	68,429	46,611	97,546	97,546	0
El Capitan	15,525	15,525	0	19,228	19,228	0
Descanso	137,219	142,336	5,117	294,816	294,816	0
TOTAL	359,700	599,865	240,165	865,654	866,689	1,035

Source of data for before start of Operation Gatekeeper: Unpublished data, courtesy of the U.S. Forest Service.

of the study period in 1999. Figure 2 shows the location of these new trails. It can be seen that the additional trails were especially created in the more southerly subareas, which are the areas closest to the U.S.-Mexico border, representing the places where illegal immigrants will first enter the area and where their impact will probably be felt even if they are subsequently apprehended before reaching the more northerly subareas. The data in Table 1 also show that very little creation of new roads occurred during this time period, and that what did occur was concentrated in the Hauser subarea, the one that is most southerly and thus closest to the U.S.-Mexico border.

The amount of ground cover disturbed was calculated using trail width measurements taken during the course of mapping trails in Hauser Canyon. The average trail width was calculated by taking the mean of these measurements. The total area of ground cover disturbed was calculated by taking the average trail width and multiplying it by the total trail length, as follows:

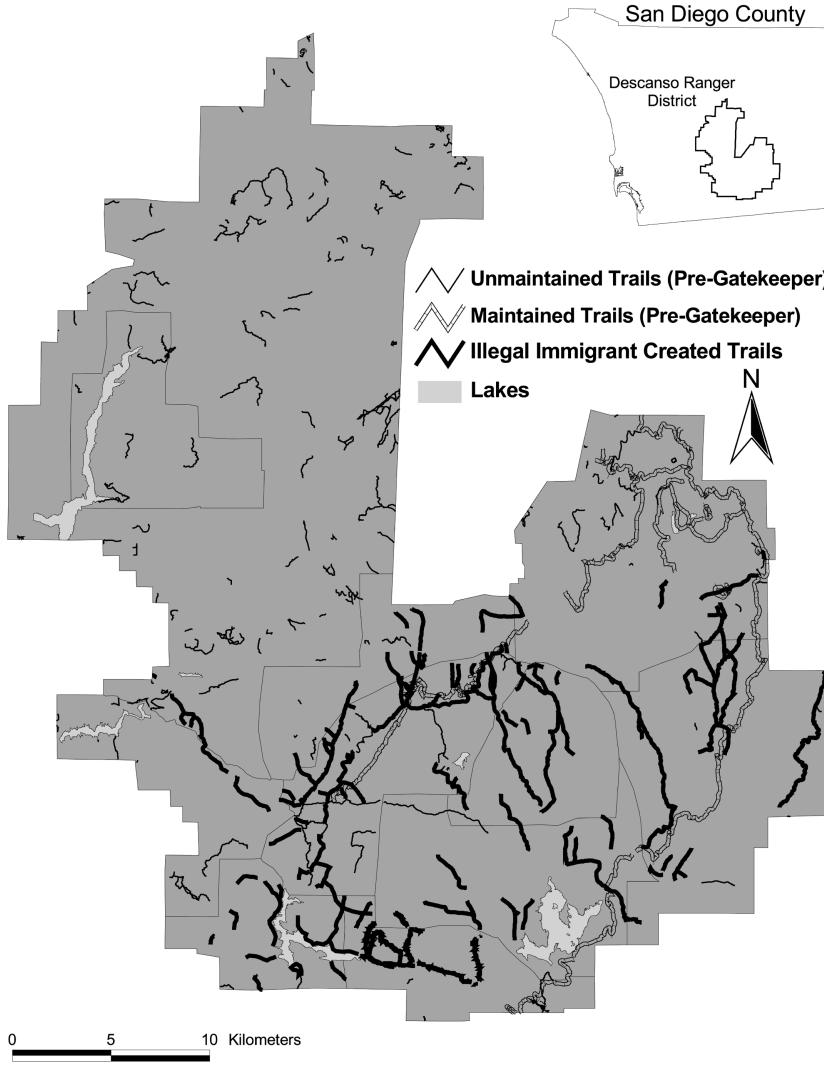

Figure 2 *All pre– and post–Operation Gatekeeper trails.*

$$0.85 \text{ meters} \times 240{,}165 \text{ meters} = 204{,}140 \text{ square meters} \quad (1)$$

Thus, we estimate that the creation of new trails disturbed a total of 204,140 square meters of area, apportioned by area according to the length of new trails created.

Data on litter collected were available for 1997 through July of 1999. The amount of litter collected (weight) was based on the number of garbage bags filled. Each bag was assumed to weigh 4.5 kilograms (Woychak, interview, 1998). The amount of litter collected (weight) for each subarea was compiled on a monthly basis and then summarized annually. The total amount of litter collected was calculated from these annual summaries. Table 2 shows the ratio of kilograms of litter per 100 hectares over these three years. Overall, 15,673 kilograms of litter have been recovered. Not surprisingly, the greatest amount of litter was found in the Pine Creek subarea, which is also the area that saw the greatest absolute increase in the length of trails during this period of time. At the same time, litter tended to accumulate somewhat farther north of the border than where the trails are originating, which is consistent with the idea that litter is associated especially with campsites and that campsites will be located a bit north of where people initially enter the national forest after crossing the border. Overall, the Pearson product-moment correlation coefficient between the amount of trail created and the amount of litter is +0.63.

Data on the number of illegal campfires discovered were available for 1996 through June of 1999. Forest Service fire prevention personnel counted campfires during patrols throughout the Descanso Ranger District. Every time a campfire or the remains of a campfire was discovered, its location was recorded and it was eradicated so that the same campfire would not be counted again. The number of illegal campfires in each forest subarea was compiled on a monthly basis and summarized annually. The size of each forest subarea was computed within the ArcInfo GIS environment. The total number of campfires discovered was calculated from these annual summaries. Table 2 shows the ratio of illegal campfires per 100 hectares over the last four years. Overall, a total of 3,498 illegal campfires were discovered, with the Pine Creek subarea having the greatest number, consistent with its having the greatest amount of trash as well as the highest amount of trail creation. The correlation among subareas between the amount of trash and the number of illegal campfires was +0.65.

Data on wildfires attributed to illegal immigration were available for 1996 through 1998. Illegal immigrants presumably caused wildfires when they failed to properly extinguish their campfires or failed to take precautions with cigarettes and other burning items. Flames from campfires spread easily, particularly during dry conditions in an area that has not been burned in several years. Wildfires threaten human life and public property and can cost millions of dollars to extinguish. The number of wildfires, number of hectares burned, and amount of money spent fighting wildfires in each subarea was compiled on a monthly basis and then

Table 2 *Litter and Illegal Campfires per 100 Hectares by Subarea, 1996–1999*

Subarea	Area in Hectares (ha)	Kilograms (kg) of Litter	Kg of Litter per 100 ha	Total Illegal Campfires	Campfires per 100 ha
Loveland	5,364	780.05	14.54	92	1.72
Japatul	5,009	2,954.65	58.99	101	2.02
Pine Creek	7,973	3,986.39	50.00	947	11.88
Barrett	4,048	548.75	13.56	278	6.87
Hauser	4,374	1,061.22	24.26	655	14.98
Corral	8,948	1,823.13	20.37	363	4.06
Bear Valley	5,110	1,020.41	19.97	153	2.99
Laguna	13,667	1,848.07	13.52	556	4.07
Cameron	11,721	1,215.42	10.37	335	2.86
El Capitan	6,322	36.28	0.57	17	0.27
Descanso	40,880	399.09	0.98	1	0.00
TOTAL	113,416	15,673.47	13.82	3,498	3.08

Source: Unpublished data, courtesy of the U.S. Forest Service.

Table 3 *Hectares Burned by Wildfires and Cost of Fire Suppression by Subarea, 1996–1998*

Subarea	Total ha Burned	Amount Spent on Fire Suppression ($)	Cost ($) per Burned ha
Loveland	0.00	0	0
Japatul	1.07	9,941	9,291
Pine Creek	125.52	1,077,570	8,585
Barrett	304.29	826,950	2,718
Hauser	2.45	4,275	1,745
Corral	62.10	211,835	3,411
Bear Valley	0.16	840	5,250
Laguna	6.29	6,115	972
Cameron	28.90	98,840	3,420
El Capitan	0.00	0	0
Descanso	0.04	210	5,250
TOTAL	530.82	2,236,575	4,213

Source: Unpublished data, courtesy of the U.S. Forest Service.

summarized annually. The total hectares burned, total amount of money expended fighting wildfires, and amount spent per burned hectare were calculated from these summaries, as shown in Table 3. The Pine Creek area led all subareas with respect to wildfires, as it did for campfires, litter, and trail creation. The correlation coefficient between the number of campfires and dollars spent fighting wildfires was +0.58.

Table 4 summarizes the correlation coefficients among the environmental impact variables, calculated in terms of both the Pearson product-moment correlation coefficient and the Spearman rank-order correlation coefficient. Regardless of which measure of correlation is used among the eleven subareas, the data suggest that there is a high correlation among the environmental impact variables. Areas with a higher amount of trail creation were also associated with more litter attributable to illegal immigrants, more campfires, and more wildfires.

Estimates of Unauthorized Immigrants Traversing the Study Area

The number of immigrants passing through the Cleveland National Forest was estimated from several different sources of information. Data regarding immigrant apprehensions and immigrant traffic were available from the U.S. Forest Service. Complete data on apprehensions by U.S. Forest Service law enforcement officers during Operation Linebacker (a federally mandated law-enforcement interdiction operation designed to address the movement of smuggling and illegal border crossings into the Cleveland National Forest and East San Diego County) were available for 1997. Data from trail sensors were also available for certain areas of the forest. This information included only apprehensions made by U.S. Forest Service law enforcement personnel, and not apprehensions made by the Border Patrol in the Cleveland National Forest.

Estimates of p, the probability of being apprehended by the Border Patrol on any given attempted illegal entry, vary widely—between 0.17 and 0.75 (Espenshade and Acevedo 1995). Nonetheless, Espenshade and Acevedo were able to derive an estimate of $p = 0.32$ that any group of illegal immigrants attempting to cross the border at any one time are apprehended by law enforcement agents, in spite of any increased efforts made by law-enforcement agencies. Using this estimate of p, we can estimate that 18,313 illegal immigrants attempted to pass through the Cleveland National Forest during 1997, based upon the number of apprehensions made by the U.S. Forest Service Law Enforcement branch.

Table 4 *Correlations among the Environmental Impact Variables*

	Length of Trails Added	Amount of Litter	Number of Illegal Campfires	Ha Burned by Wildfires
Length of trails added	—	0.630** 0.573*	0.736** 0.718**	0.288 0.670**
Amount of litter		—	0.648** 0.709**	0.070 0.524*
Number of illegal campfires			—	0.259 0.743**
Ha burned by wildfires				—

** Correlation is significant at or beyond the 0.10 level (2-tailed).*
*** Correlation is significant at or beyond the 0.05 level (2-tailed).*

$$5{,}860/p = 18{,}313 \quad (2)$$

Border Patrol agents also operate in the Cleveland National Forest; both in support of and independent of U.S. Forest Service law enforcement operations (Ivan Bartolichek, law enforcement officer for the Descanso Ranger District of the Cleveland National Forest, personal communication 1999). Given this factor, coupled with the fact that the number of Border Patrol arrests is not necessarily a reliable guide to the flow of undocumented migrants (Espenshade and Acevedo 1995), it is advisable to establish a range of the number of illegal immigrants attempting to traverse the forest during any given year. Given the fact that there are only two full-time Forestry law enforcement officers tasked with patrolling the Descanso Ranger District (Bartolichek, personal communication 1999), we can hypothetically assume that the Border Patrol apprehended at least twice as many illegal immigrants in 1997 as did the U.S. Forest Service.

$$5{,}860 \times 2 = 11{,}720 \quad (3)$$

Adding the number of apprehensions made by the U.S. Forest Service to this number gave the following:

$$11{,}720 + 5{,}860 = 17{,}580 \quad (4)$$

Factoring in Espenshade and Acevedo's apprehension rate produced an estimate of:

$$17{,}580/p = 54{,}938 \quad (5)$$

Repeating this procedure, but assuming, first, that the Border Patrol apprehended as many as four times as many people as the Forest Service, and second, that they apprehended as many as six times as many people as the Forest Service, produced the following calculations:

$$(5{,}860 \times 4) + 5{,}860 = 29{,}300/p = 91{,}563 \quad (6)$$

$$(5{,}860 \times 6) + 5{,}860 = 41{,}020/p = 128{,}188 \quad (7)$$

This established a range (54,938 to 128,188) for the number of illegal immigrants passing through the forest in 1997. The middle number in this range (91,563) corresponds closely to data from two U.S. Forest Service trail sensors. The cumulative total for Sensor A showed 68,570 passing by in 1996. Sensor B showed that 8,681 passed by over a four-month period before it ceased operating. To extrapolate the number from this sensor out over one year's time, we compared it to the data from Sensor A. 25,577 had passed Sensor A at the same time. This represents 37 percent of the total for that sensor in 1996. Assuming immigrants passed Sensor B at the same rate as Sensor A, 8,681 is 37 percent of the total for that sensor for that year. Thus, 23,462 passed Sensor B in 1996.

$$8{,}681/0.37 = 23{,}462 \quad (8)$$

This number, added to the number derived from Sensor A, showed a total immigrant passage of 92,032.

$$23{,}462 + 68{,}570 = 92{,}032 \quad (9)$$

This corresponds closely to the middle number in the range (91,563) we established above that assumed the Border Patrol apprehended four times as many illegal immigrants as the U.S. Forest Service. Using the mean of these two numbers, a rough count of the number of immigrants passing through the Cleveland National Forest in 1997 is 91,797:

$$91{,}563 + 92{,}032/2 = 91{,}797 \quad (10)$$

Although we were able to make this detailed calculation only for 1997, we assumed that the pattern of immigrants traversing through the area each year would be consistent with the pattern of apprehensions each year made by the Campo/Boulevard Border Patrol Station—the nearest station to the study site. Thus, we created an estimate of the rate at which immigrants have passed through the forest since the start of Operation Gatekeeper by looking at apprehension data from the Campo/Boulevard Border Patrol Station. We began with the number of apprehensions for each year from the Campo/Boulevard Border Patrol station and then incorporated Espenshade's (1994) estimate of the percentage of immigrants caught during a crossing attempt to calculate the estimated number of immigrants passing through the area. Table 5 shows these results. We thus estimated that between 1994 (just before the start of Operation Gatekeeper) and 1999 (the end of the 1998 fiscal year), there were 311,176 unauthorized immigrants passing through the study site. Less than 1 percent of these passages occurred in 1994; the number increased dramatically in 1995, and then rose to a peak in 1997. We assume that the environmental impact of

Table 5 *Estimates of Unauthorized Immigrants by Year, 1994–1998*

Fiscal Year	Number of Immigrants Traversing Through Region[a]	Percent of Total by Year	Estimated Number of Immigrants Traversing the Descanso Ranger District[b]
1994	7,821	0.8	2,489
1995	160,706	17.9	55,701
1996	234,991	26.2	81,528
1997	264,194	29.5	91,797
1998	229,478	25.6	79,661
TOTAL	878,717	100.0	311,176

[a] *Based on apprehensions by nearest Border Patrol station.*
[b] *Based on 1997 calculations and annual pattern of all apprehensions in region.*

Table 6 *Environmental Impact on Study Site per 1,000 Immigrants*

Environmental Impact Category	Total Impact	Impact per Unauthorized Immigrant
Length of new trail created in meters	240,164	772 meters per 1,000 immigrants
Area disturbed by trail creation in square meters	204,140	656 sq m per 1,000 immigrants
Litter left behind in kilograms	15,673	50 kg per 1,000 immigrants
Illegal campfires	3,498	11 campfires per 1,000 immigrants
Hectares burned per wildfire	531	1.7 hectares burned per 1,000 immigrants

the immigrants was proportionate to their number, and that therefore the distribution of immigrants by year can serve as a proxy for the environmental impact per year.

Per-Immigrant Impact on the Environment

We now have the data required to estimate the per-immigrant environmental impact within the study area. Between the start of Operation Gatekeeper and the end of the study period in 1999, 240,164 meters of new trail were created in the Descanso Ranger District. Because of the restrictions placed by the U.S. Forest Service on legal campers, we attribute all of this trail creation to the unauthorized immigrants traversing the area during this period of time. Since we estimate there to have been 311,176 illegal immigrants, the impact per 1000 immigrants is thus 772 new meters of trail for each 1,000 immigrants passing through this section of the forest. As shown in Table 6, we estimate that the area disturbed in the creation of new trails was 656 square meters per 1,000 immigrants. There were an estimated fifty kilograms of litter left behind per 1,000 immigrants, and eleven illegal campfires per 1,000 immigrants, which led to an average of 1.7 burned hectares from wildfires per 1,000 immigrants.

Discussion and Conclusions

Operation Gatekeeper has successfully pushed illegal immigrants from their traditional crossing points near Imperial Beach and San Ysidro into the more inhospitable and rugged backcountry of eastern San Diego County. Little evidence exists, however, to show whether Gatekeeper has truly been effective in preventing and/or deterring illegal entry from Mexico into the United States. According to the General Accounting Office, no reliable data exist to indicate that once they are apprehended, illegal immigrants will not attempt to cross again (Martin 1999). In fiscal year 1999, the INS apprehended some 470,499 illegal immigrants in Arizona, double the number they apprehended there in fiscal year 1995. This would indicate that the flow of illegal immigrants attempting to enter the country has not stopped, but has shifted to a different area where programs similar to Gatekeeper are not in place (Martin 1999). Research by Cornelius and Kuwahara (1998) indicates that not only have employers in San Diego seen no change in the number of illegal immigrants applying for jobs since the inception of Gatekeeper, but many have noticed an increase in the number of immigrant job seekers since Gatekeeper began.

While the success of Operation Gatekeeper as a means of preventing and/or deterring illegal immigration is still undetermined, the environmental impacts that have resulted are, in our view, unmistakable. From Otay Mountain east to the Imperial County line, San Diego County has seen portions of its backcountry disturbed by the passage of thousands of illegal immigrants. This damage, manifested in the form of unmanaged footpaths and campsites, illegal campfires, wildfires, and litter, is so widespread that it may be years before the long-term impact is fully understood and even longer before the area recovers. Studies performed on

campsite degradation in Western (arid) regions have found minimal recovery occurring over the three- to five-year period since the campsites have been closed (Cole 1988).

The Descanso Ranger District of the Cleveland National Forest has been hit particularly hard by this influx of illegal immigrants and their pursuers, the U.S. Border Patrol. Hundreds of thousands of meters of new trail have been added and hundreds of thousands of square meters of ground have been disturbed. The U.S. Forest Service, which was taken completely by surprise by these events, has worked hard to catch up with the damage to sensitive portions of their ecosystem. However, they are barely able to keep pace with the damage currently being done and are still behind in making repairs to damage inflicted early in this phenomenon.

In conclusion, we note that our quantitative estimates of the impact per immigrant is almost certainly a conservative set of estimates. It was not possible to map every single trail created by illegal immigrants during the course of this study, because there are simply too many. Rather, this investigation focused on the primary north/south immigration routes as well as the main east/west connector routes, since that is where the majority of the traffic occurs. Further research could result in a more statistically accurate quantitative assessment, but such research would require resources beyond the scope of the current study. Although environmental impact statements are not routinely part of the background analysis that goes into legislation dealing with illegal immigration, our research suggests that the environmental impact of shifting illegal crossings to wilderness areas is significant and potentially very costly both to the environment and to taxpayers. ■

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