

Mapping Migrant Deaths in Southern Arizona: The Humane Borders GIS

John F. Chamblee,¹ Gary L. Christopherson,² Mark Townley,³ Daniel DeBorde,⁴ Rev. Robin Hoover⁵,

Abstract

Thousands of migrants die annually crossing the desert into the United States. Humane Borders is a Tucson, Arizona non-profit agency that provides migrants with strategically placed drinking water stations. We also work for immigration reform. Through cooperation with the U.S. Border Patrol and local medical examiners we produce maps showing the locations where migrants died. After ESRI donated ArcView 9.1, we launched an ambitious GIS program. Using personal geodatabases, we first created better migrant death maps. We then built Spanish-language warning posters that deter entry into the United States and warn migrants away from the deadliest parts of the desert. Recently we developed viewshed models of cellular phone service illustrating how better coverage would save lives by allowing migrants to call for government rescue. This paper demonstrates how GIS furthers our efforts to – in the words of Humane Borders’ President, Rev. Robin Hoover – “take death out of the immigration equation.”

¹ Department of Anthropology, University of Arizona

² Center for Applied Spatial Analysis, University of Arizona

³ President, Humane Borders

⁴ Peace Corps Volunteer

⁵ Founder and Spokesperson, Humane Borders; Pastor, Tucson First Christian Church

Introduction

Global cross-border immigration rates currently stand at unprecedented levels. Along United States' border with Mexico this trend exists as the largest continuous migration in recorded history. According to the Bureau of Labor Statistics (2005), over 12.1 million people have entered the United States from Mexico illegally between 1990 and 2004. Many have since returned to their home countries in Mexico or Latin America, but recent estimates suggest that about 7.5 million Latin Americans are currently in the United States illegally (for example, Johnson 2004). Due to the length of time that this crisis has continued and the types of jobs these migrants do, America is now dependent on labor provided by illegal immigrants (Paral 2005).

As in other periods in U.S. history, the demographic and economic changes brought about by this influx ignited strident debates about immigration, civil rights, and the rule of law. In post-9/11 America, such media-driven and politically charged debates tend to generate more heat than light. As a result, a crucial facet of the "immigration question" is lost among concerns over security, economy, and national identity. Reporters, politicians, and citizens rarely stop to think about the human cost of this mass migration or, worse yet, about the ethics of forcing workers on whom the American economy now depends (for better or worse) to cross the deadliest landscape in the lower 48 states.

As people who spend a great deal of our free time not only considering this topic, but also doing something about it, we find the omission unacceptable. It is the purpose of this paper, therefore, to 1) argue that current U.S. border policy has helped send thousands of Mexicans and Central Americans to their deaths in attempts to cross the Sonoran Desert of southern Arizona; 2) tell the story of Humane Borders, an organization dedicated to helping save the lives of these immigrants; and 3) demonstrate how geographic information systems (GIS) enabled Humane

Borders to improve its operations 4) and place GIS technology, and a functioning moral compass, front and center in the United States' immigration and border policy debate.

A Brief History Migrant Deaths in Arizona

This paper consists of analytical and historical sections. In the first section, brief histories of the migrant death problem and of Humane Borders' response precede a description of the Humane Borders GIS and explanation of data collection methods and problems. The second section presents a brief analysis exploring relationships between migrant deaths and natural/cultural landscape features,. Finally, we present a preliminary quantitative assessment of the Humane Borders humanitarian aid effort. Though deaths of individual migrants will often appear as a dot on a map in these pages, it is important to keep in mind that each dot represented a human being that was and continues to be loved and remembered (see Figure 1).



Figure 1: A well maintained memorial in the desert near Tucson..

Migrant Deaths and Border Policies: Connections in Recent History

The United States Border Patrol's Strategic Plan, issued in 1994, outlined a program for sealing off urban, high traffic areas of illegal immigration in Arizona, California and Texas, thereby forcing migrants into desert areas in western California, southern Arizona, and New Mexico. This strategy was built around the philosophy of "prevention through deterrence" (U.S. Border Patrol 1994:6) and founded on the assumption that, by forcing migrants into "more hostile terrain" that was "less suited for crossing and more suited for enforcement," it would be possible to "gain control of southwestern border" (U.S. Border Patrol 1994:7 and 11) The project was designed to be undertaken in three phases, known later by the code names "Operation Gatekeeper" and "Operation Hold the Line" (Phase I, San Diego and El Paso), "Operation Safeguard" (Phase II, Tucson), and an as yet unnamed operation along the "rest of the border" (Phase III) (U.S. Border Patrol 1994; U.S. Civil Rights Commission 2002). During each of the early phases, a major indicator of success was to be a reduction in "serious accidents" among illegal immigrants – especially in the number accidental deaths due to, among other things, dehydration and exposure to desert heat (U.S. Border Patrol 1994:9 and 10).

Research by Wayne Cornelius (2001) revealed that Phases I and II of this issues did not reduce overall migrant traffic or the incidence of migrants deaths, but simply shifted the problem to remote and dangerous parts of the southwestern deserts, where death rates increased further. The 1994 plan did not anticipate such an outcome, instead expecting a shift in illegal entries to the "water boundaries" of the United States (U.S. Border Patrol 1994:11). The U.S. Commission on Civil Rights (2002 and 2003) asserts that over 2,200 people have died as a consequence of the Border Patrol's Strategic Plans. From year to year, definite figures are elusive, but the best

estimates of several groups (Figure 2) indicate that, in the Tucson Sector alone, deaths increase by 30 to 40 people per year (Chamblee et al. 2006).

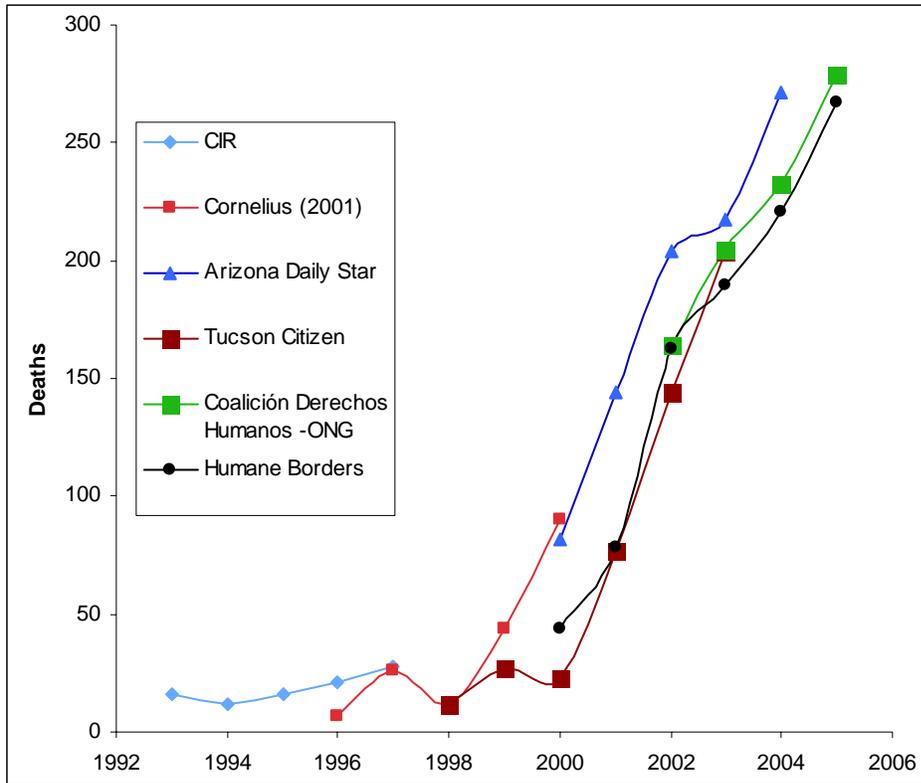


Figure 2: Estimates of Migrant Deaths from 1992 through 2006 (from Chamblee et al. 2006)

Tucson Responds with Humane Borders

In 1999, between 20 and 50 migrants died (Cornelius 2001; Chamblee et al. 2006). Humane Borders was founded the following year, in response to this annual crisis that is now six times more serious. On Pentecost Sunday (June 11, 2000), members of the Tucson Faith Community met at the Pima Friends House and were led in the Quaker Query method to answer two questions: 1) What steps could be taken to respond with compassion to the migrants who were risking their lives crossing the U.S.-Mexico border? 2) How could we work together to change the system that was putting these people's lives in peril?

A variety of goals were developed that day, but over the years, two activities became the centerpieces of the Humane Borders mission: the provision of water to migrants as they cross the

desert and efforts to save lives by educating and engaging the media, the general public, the migrants themselves, and government officials on both sides of the border about the possible policy changes and local practices that would lead to a safer and more hospitable border. Humane Borders officers and volunteers seek non-adversarial, public, open, transparent, courses of action and always work within the bounds of law. We cannot advocate for the U.S. to constrain itself to exert its authority and jurisdiction in a lawful and moral manner if we do not do so ourselves.

Humane Borders maintains 80 water stations in southern Arizona and northern Mexico. Each consists of one to three sixty gallon tanks and a blue flag mounted on a thirty foot steel pole (Figure 3). Water is distributed via a fleet of four-wheel-drive trucks equipped with 100 to 300 gallon water tanks (Figure 4). During the summer months, these trucks, driven exclusively by volunteers, operate seven days a week testing, sterilizing, and replenishing water supplies. About 85% of the operating budget goes to truck maintenance and operation. During each trip to a water station volunteers record the number of gallons needed to refill the tanks. Since March of 2001, when the first stations were established, Humane Borders has distributed over 64,000 gallons of water.



Figure 3: Collecting GPS coordinates for a water station.



Figure 4: A Humane Borders truck and volunteer crew delivering water.

In addition to this central mission of providing water to the stranger, Rev. Robin Hoover and other volunteers seek to educate the public and government officials through mass media contacts, education programs, and research. Beginning in 2002, Humane Borders volunteers have produced an annual map showing the locations of every documented migrant death with a known location. Initially, these maps were made using a combination of off-the-shelf, sportsman grade, GPS navigation software and Adobe Photoshop – a slow, painstaking, but successful process (Figure 5). In 2004, ESRI donated a license for ArcView and members of the local GIS community (including the authors) began building a GIS for managing water stations and migrant death data. The GIS is an ongoing project, again maintained solely by volunteers. This paper represents the first efforts to use the GIS for quantitative analysis.

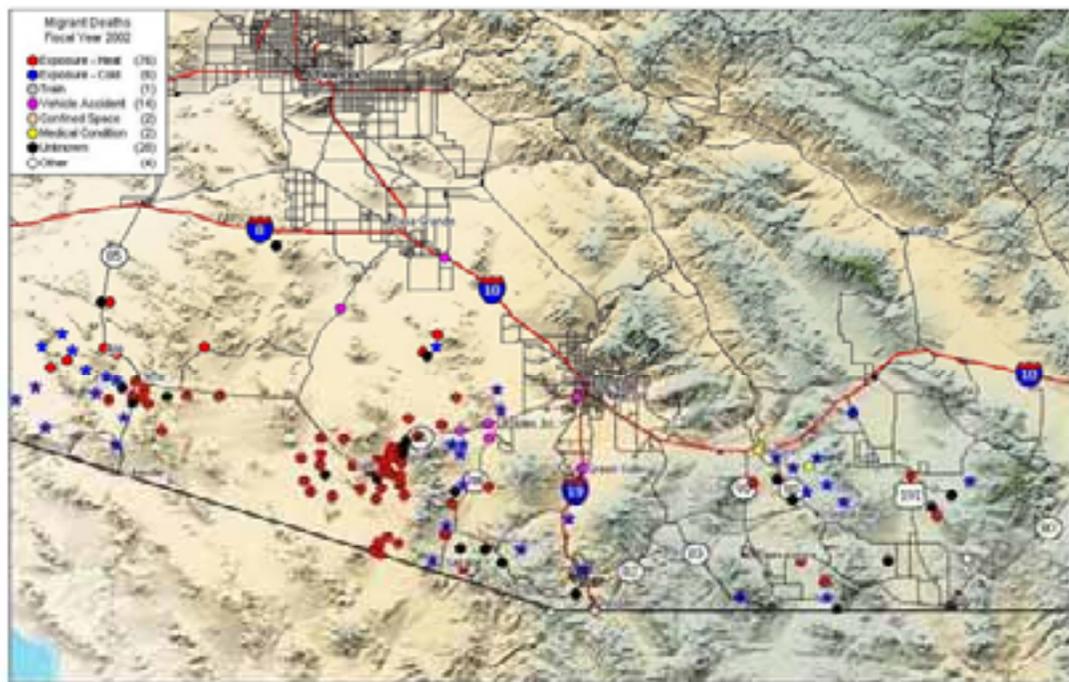


Figure 5: A Humane Borders death map from 2002.

The Humane Borders GIS: Structure and Content

The Humane Borders GIS and information management system consists of one personal geodatabase stored as a Microsoft Access file and an additional Microsoft Access application for entering and managing data concerning water stations. The water station database is designed to streamline the input, storage, organization, and analysis of data collected on the daily trip sheets volunteers complete during water station maintenance runs. The personal geodatabase consists of three feature datasets: background and environmental data, migrant death data, and data concerning water tanks, cell towers, and rescue beacons established by the U.S. Border Patrol. Each feature dataset is described in further detail below.

The background feature dataset consists of line and polygon feature classes describing roads, railroads, power lines, drainages, vegetation classes, municipal and county boundaries – as well as surface management and responsibility for land parcels. Background data comes from the Arizona Land Resource Information System (ALRIS 2006), managed by the Arizona State Land Department. These data sets are typically derived from either the Census Bureau’s TIGER files or the Arizona GAP Analysis Project. Thirty and ninety meter digital elevation models were built at the University of Arizona using USGS and SRTM data available from the USGS and the Arizona Regional Image Archive (ARIA 2006).

Water station, and rescue beacon locations are typically derived from GPS readings. Front-line officers from the Tucson sector of the U.S. Border Patrol pooled resources to purchase and established rescue beacons at several points in the desert, especially in areas where Humane Borders has been prohibited from operating. The Border Patrol provided locations of these beacons via their own GPS units. Except for water stations in Mexico, or those located on private land and maintained by the landowner, all water stations have been located with sportsman-grade

GPS units. A project to record each station with professional grade, Trimble hand-held GPS units is underway. Cell tower locations were derived from consultations with cellular service providers and cellphonereception.com.

Data for the migrant death feature dataset are not as straightforward those previously discussed. Unlike other data, the processes for the collection and distribution of migrant deaths take place in the setting of local, state, and federal bureaucracies. Because the Border Patrol has articulated that a long-term decrease in migrant deaths is an indicator of strategic success, possible incentives to manipulate, control, or withhold data cannot be overlooked as sources of bias. This politicization of data is the greatest challenge Humane Borders faces in building a feature dataset of migrant deaths in southern Arizona.

At present, the feature dataset consists of two feature classes. Spatial data concerning deaths from U.S. Government Fiscal Years 2000 through 2003 (or October 1, 1999 through September 30, 2003) come exclusively from the Border Patrol. Agents mark the locations of migrant deaths with sportsman-grade GPS units. In addition to Border Patrol data, Humane Borders also collects migrant death data from all southern Arizona County Medical Examiner's offices and the Mexican Consulates located in Arizona. We are working to integrate all years in the GIS, but currently, only the 2004 feature class includes all these sources.

Our records stand as a virtual monument to those who have died, so we make every effort to ensure that they are as accurate as possible. We generally use data from two or three sources to complete each record in the system. Once the data is collected from the different sources, we use a systematic, but manual procedure to match up data records from each source and combine them into one record. We currently receive these data in hard copy and enter it into a digital spreadsheet. We then copy the Border Patrol data and the Consulate data if any into the same

spreadsheet maintaining the same data columns. Once the data is all in the spreadsheet, it is sorted by date. Our goal is to correlate records from each source describing the same death. One or more of the following can suggest a match:

- Matching names and reporting dates for migrant deaths.
- Matching reporting dates, along with matching ages and sex.
- Matching dates and locations in the ME records that are within a mile of a Border Patrol GPS location.

If none of the data from the different sources conflicts, we will consider matching records if the dates are the same. While we prefer to have more corroborating information, we want to err on the conservative side and not over report deaths. If we cannot be sure of M.E. and Border Patrol record correlations, we use the Border Patrol data, as the spatial information in the M.E. records and consulate sources can be problematic and vague. These data are not perfect, but, as noted in Figure 2, they are consistent with other yearly estimates for the total numbers of deaths.

County Medical examiners and the Mexican government continue supporting mapping projects with their data. Until 2004, the Border Patrol cooperated as well, providing quarterly updates and yearly summaries in electronic format. But, since August, 2004, the Border Patrol's Tucson Sector has required Freedom of Information Act (FOIA) requests, which they take up to 10 months to fulfill. Border Patrol policies are the greatest barrier to producing timely maps. As of this writing, the Border Patrol had still not fulfilled our FOIA request for Fiscal Year 2005 migrant death information.

Humane Borders GIS Products: Education North and South of the Border

Through GIS, Humane Borders has dramatically expanded the role of maps in its education efforts. The most current map of migrant deaths, for fiscal year 2004 (Figure 6),

provides readers with a much more detailed view of the relationships between deaths, water tanks, and surface management and responsibility. Since state, local, tribal, and even various federal agencies differ in their approaches to humanitarian aid, correlations between death rates and surface management and responsibility are a key variable in local border policy debates.

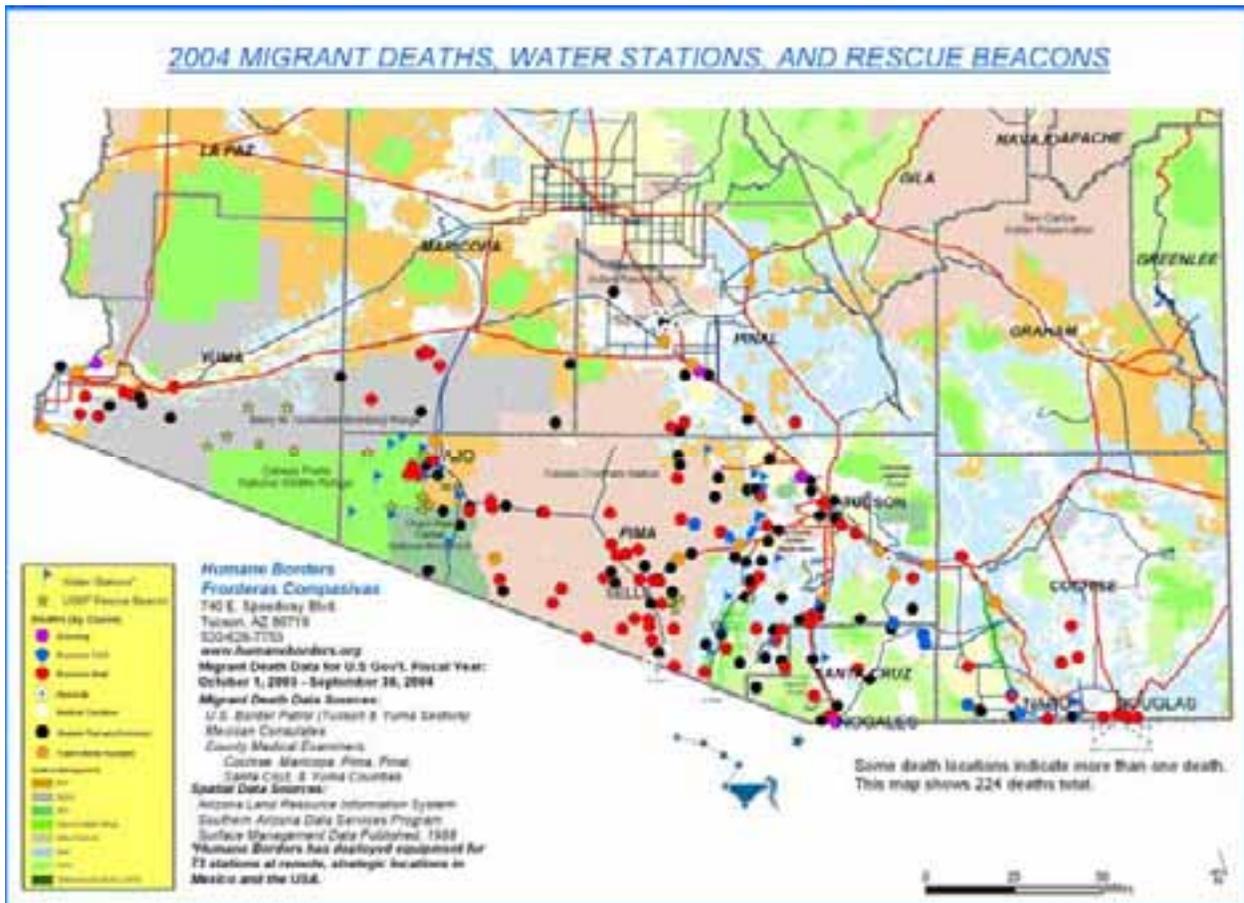


Figure 6: 2004 Map of Migrant Deaths.

In 2005, President Bush announced additional funding initiatives for new technology on the border. Humane Borders, in cooperation with Water Stations, Inc. of California, launched a campaign to earmark some of this money go toward the construction of additional cell phone towers in the desert. The goal was to encourage saving lives by increasing opportunities for the successful rescue of migrants who report themselves as lost using their own cell phone.

The map shown in Figure 7 is an estimate of cell phone coverage in the deserts of western Arizona and eastern California that was generated by combining Humane Borders feature datasets with data concerning migrant deaths in California and methods developed elsewhere for estimating cell tower coverage (Dodd 2001). Although the campaign was not successful, the large gaps in coverage reiterate the risks migrants take in crossing the desert and the empty terrain comprising the southern border.



Figure 7: Cell Tower Expansion Proposal Map

To date, Humane Borders’ most ambitious GIS-driven project is the design and distribution of four warning posters, targeted at Spanish-speaking audiences still living in Mexico and Central America. Evidence from interviews with migrants and discussions with officers from Mexico’s border aid agency, *Grupo Beta*, indicates that most migrants have an inaccurate picture of the challenges facing them in crossing Mexico’s border with Arizona. Local smugglers, or *coyotes*, frequently describe walking distances between the border and Tucson,

Phoenix, or even Las Vegas in terms of a few hours, rather than several days. While the U.S. Border Patrol and *Grupo Beta* both make education efforts, such attempts are under funded.

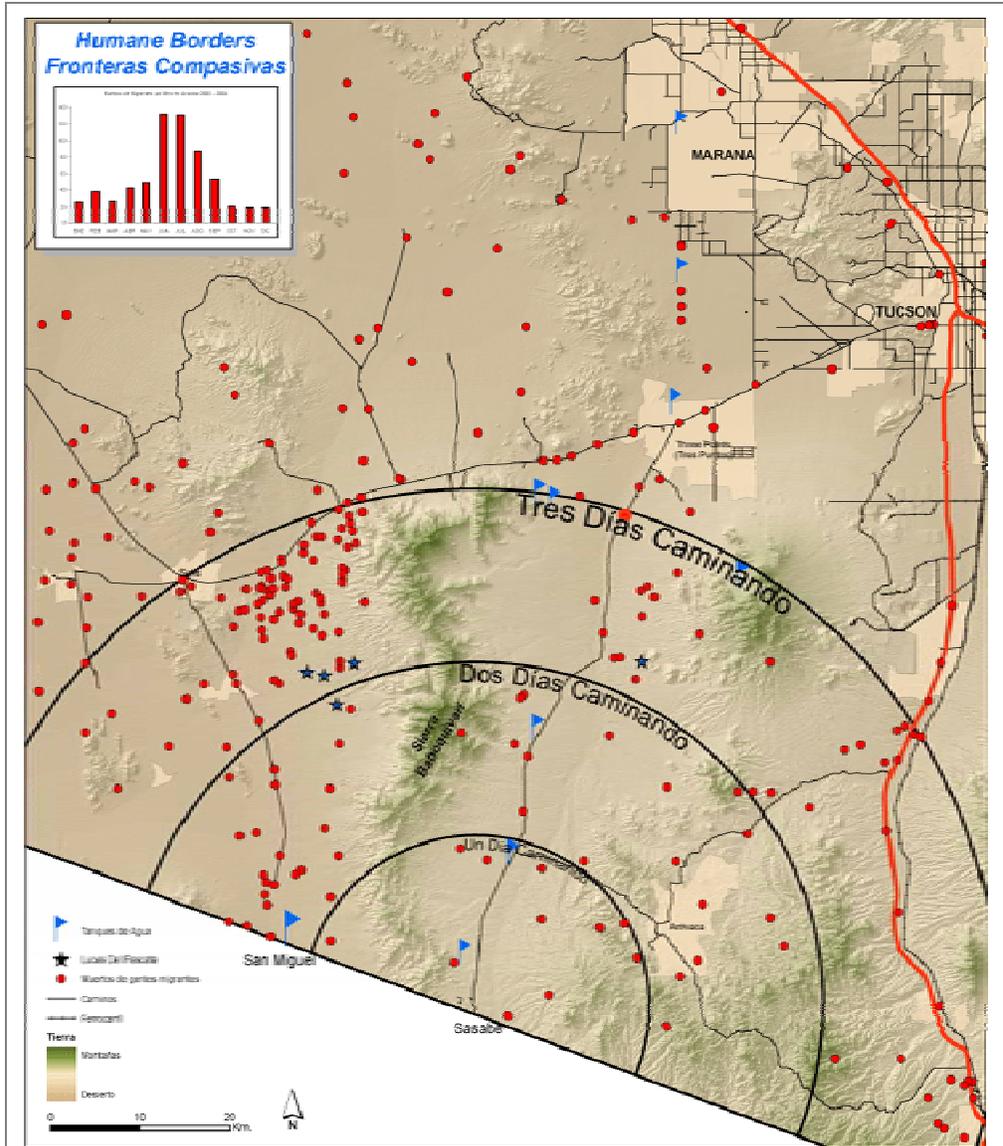


Figure 8: Warning Poster for the Sasabe Corridor.

To compensate for these problems and give migrants an accurate picture of the risks they face, Humane Borders designed posters major migrant corridors in southern Arizona. The poster for the Sasabe Corridor is shown in Figure 8. The scale of these posters (1:200,000 for an 18” x 24” printout) is not sufficient for navigation. In addition to showing deaths, the approximate locations of water stations, and an approximation of walking distances in terms of days, the posters strongly advise migrants to avoid the trip altogether. A chart of deaths by the month in which they occurred illustrates the high correlation between the risk of death and a summer crossing. Posters also show tips for slightly reducing the risks involved and a of list emergency telephone numbers.

The posters are an education tool, designed around the principle that the first rule of ethics is informed consent. In February of 2006, Humane Borders and the Comisión Nacional de Derechos Humanos de México – an independent, but government-funded agency – announced an initiative to print and distribute 70,000 of these posters in “sending communities,” or areas with high emigration rates, across Mexico. By placing the posters in communities far from the border, both organizations hoped to inform migrants of the risks they undertook before ever leaving home. An Associated Press report of the Mexico City press conference announcing the initiative inaccurately described the posters as “maps to aid migrants in crossing the desert.” As major news agencies picked up the report and repeated this mischaracterization, some media figures denounced the Humane Borders education effort as “aiding and abetting” criminal behavior.

Before the news cycle ended, Michael Chertoff denounced the project and Mexican Human Rights Commission determined that they could no longer participate. However, searches of Google News at the height of the reporting (January 28, 2006) showed that 611 news agencies picked up the story. It appeared in Al Jazeera, the Moscow Times, and numerous other countries.

The corridor maps themselves appeared on Good Morning America, CNN, and elsewhere. Presently, the corridor maps are being distributed via the Humane Borders website (www.humaneborders.org) and through other faith-based channels in Mexico and Central America.

The events surrounding the warning poster distribution project was one of the small pebbles that set off the current avalanche of controversy concerning illegal immigration. The overall trajectory of that debate is emblematic of the character of the immigration debate generally. Despite their representation in the media, the posters themselves were intended as educational tools that gave truthful assessments of risk. It takes four days to walk to Tucson, Arizona, not four hours. Our main goal is to save lives. Elderly people, pregnant women, and families with young children deserve to know the risks they face and make an informed decision as to whether or not the economic hardships they face are greater than the risks posed by the landscape of southern Arizona.

A truthful dialogue involving all interested parties must include the migrants themselves. Irrespective of the deterrent effect (or lack thereof) that this dialogue has on illegal immigration, it remains true that a clear-headed assessment and forthright communication of facts will be the only route to a solution for the immigration crisis. Toward this end, we now offer up for public assessment and analysis of our own efforts to understand and combat the migrant death issue.

GIS and the Migrant Death Feature Datasets

In addition to data management and humanitarian education, the Humane Borders geodatabase lends itself to a variety of analytic techniques. This phase of the project is in its infancy, concentrating on simple relationships between migrant deaths and the natural and human environment along the Arizona border. In this section of the paper, questions concerning the relationship between migrant deaths and the international border, between deaths and travel routes, and between deaths and humane border water tanks will be discussed. The data used in these analyses are limited to the death data provided by the border patrol, along with background data for major roads and drainages, the international border, and the Humane Borders water station locations. Spatial extents were both regional (southern Arizona) and local (the Sasabe migration corridor).

Southern Arizona and Migrant Deaths

Extents for the southern Arizona region were determined using both political boundaries and the Border Patrol death data (Figure 9). The boundaries on the west, south, and east matched the borders of Arizona and the northern extent was set by the northernmost migrant death. Within this area, a total of 546 deaths were recorded by the Border Patrol between Fiscal Years 2000 and 2004. Cause of death included exposure (337), accident (81), homicide (11), drowning (4), confined space (2), previous medical condition (2), and unknown cause (109). In the following analyses only deaths by exposure were considered. Finally, for the purpose of statistical comparison, a feature class of 5000 randomly located points was created within these same extents.

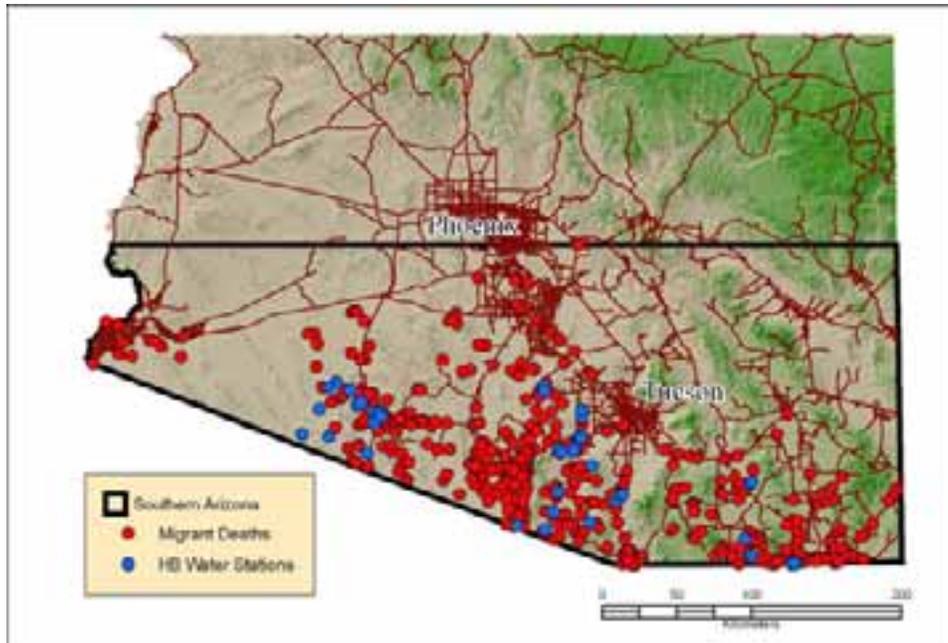


Figure 9: Map of southern Arizona showing location of illegal immigrant deaths and Humane Borders water stations

When deciding where to concentrate resources, it is important to know where deaths are more likely to occur. This raises questions about the relationship between migrant deaths and the US/Mexico border, and between migrant deaths and travel routes. To answer these questions Euclidean distance surfaces were created for the international border, major roads, and major drainages. These surfaces were sampled using the death data and the random point feature classes. Results were subjected to a Kolmogorov-Smirnov (KS) statistical test, and cumulative proportion graphs were created as a visual aid.

Death and the Border

Looking at the distribution of death locations in southern Arizona, it is visually clear that migrant deaths are more likely to occur to the south, near the border, than to the north (Figure 9). This is confirmed by the KS test, as seen in Figure 10. The KS is a non-parametric statistical test that measures the difference between the cumulative proportions of two samples. This test locates the point at which the two samples are farthest apart. (In the case of death by exposure that occurs approximately 50,000 meters from the border (Figure 10.) It then subtracts the lesser proportion from the greater proportion and returns this number as the test statistic (d).

Significance at the five percent level is reached if $d \geq \frac{1.36}{\sqrt{n}}$; where n is the number of the phenomena being studied (migrant deaths). Because the square root of n serves as the denominator, sample size greatly affects the point at which the difference between samples becomes significant. A large sample size lessens the difference necessary for significance to be reached, while a small sample increases it (Kvamme, 1990). In the case of death by exposure, with a sample of 337 migrant deaths, the difference must be greater than 0.074 for significance at the 5% level. In fact the difference between these samples was 0.493. The probability (p) of this test statistic occurring by chance is $p < 0.001$, indicating that distance to the border is a significant factor in migrant deaths.

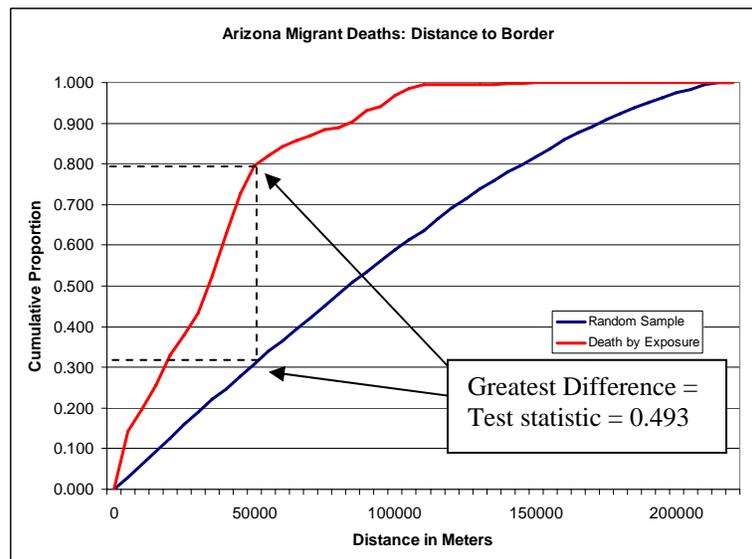


Figure 10: Distance to international border: cumulative proportions for death by exposure and random sample in southern Arizona

In addition to visualizing the test statistic, the cumulative proportion graph also provides details about the direction of significance. Because the line representing the cumulative proportion for migrant deaths is to the left of the random sample line, it indicates that deaths occurred closer to the border than would be expected if the process were random, confirming the visual pattern discerned in Figure 9. Although there are likely mitigating factors, primarily that increased enforcement presence along the border makes the discovery and identification of

migrant deaths more likely close to the border, this analysis indicates that humanitarian resources are better spent near the border.

Migrant Deaths and Travel Routes

Migrants use a variety of travel routes, including roads, drainages, formal and informal trails. As more people travel a particular route, it becomes more likely that there will be deaths along that route. Of the routes available to migrants, major roads and drainages provide the easiest, quickest travel, but it is difficult to visually judge the relationship between migrant deaths and these features. KS tests were used to determine their significance.

Migrant Deaths and Roads

Roads provide the best travel routes for moving quickly north from the border. It is also true that enforcement agencies patrol these roads on a regular basis. Knowing this, migrants must decide whether it is best to travel the roads or to avoid them. For Humane Borders, the question is one of resource allocation. That is, should resources be spent near roads, or away from them? The KS test for distance to roads produced a test statistic of 0.133, with a probability of $p < 0.001$. As with the previous analysis, the cumulative proportion line for death by exposure is to the left of the random sample, indicating that deaths are more likely to occur near roads than away from them (Figure 11). This may indicate that roads play an important role in migrant travel (but see below for alternate explanations). In fact, 50% of all deaths occurred within 2.5 kilometers of main roads, and fully 90 percent within 9 kilometers.

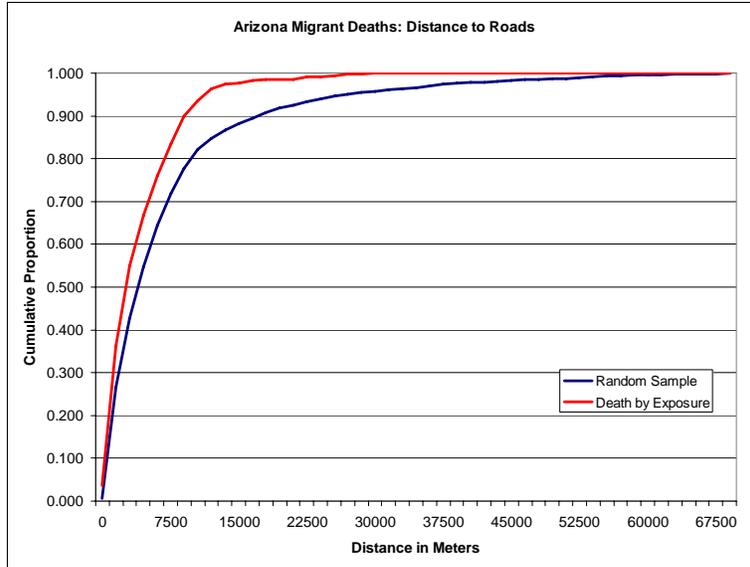


Figure 11: Distance to roads: cumulative proportions for death by exposure and random sample in southern Arizona.

Migrant deaths and Drainages

Providing relatively unimpeded travel, some cover from enforcement agents, and some shaded riparian areas, another potentially important travel route in the Arizona desert is provided by drainages. Dry, except immediately following a rainfall event, drainages in the southwestern U.S. provide a network of routes that can be used as a kind of natural highway; however, because drainages don't necessarily move in the direction that migrants want to travel their importance as transportation routes is unclear. An important question for Humane Borders is whether or not drainages are used by migrants for transportation. For this analysis, only major drainages, those more likely to run for longer distances and provide more opportunity for flatter terrain and riparian habitats, were used. A KS test indicates that there was a relationship between migrant deaths and distance to these drainages. A test statistic of 0.106 ($p < 0.002$) showed that migrant deaths were more likely to occur near major drainages (Figure 12). Though this association was not as strong as that for distance to roads, it nevertheless suggests that drainages act as transportation routes for migrants in southern Arizona. Fifty percent of exposure deaths occurred within 2 kilometers of a major drainage, and 90% within 6 kilometers. It seems clear that for

purposes of humanitarian aid, roads and drainages are important markers for identifying migrant transportation corridors, and resources should be concentrated along these features.

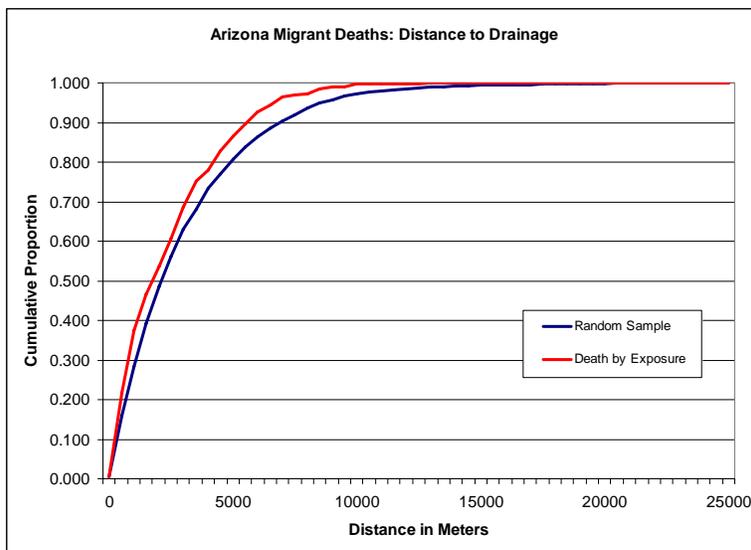


Figure 12: Distance to drainage: cumulative proportions for death by exposure and random sample in southern Arizona

Although this evidence for the use of drainages and roads as transportation routes is encouraging, it is important to remember that these patterns are also a reflection of processes used to find and identify migrant bodies. That is, just as roads and drainages provide the easiest and quickest transportation routes for migrants, they also are the most commonly traveled routes used by those who find and identify migrant remains. This opens the possibility that the patterns of migrant death may simply reflect bodies that are easy to find, not the real problem away from easily traveled routes.

Deaths along the Sasabe/El Tortugo Migrant Corridor

In addition to the southern Arizona regional analyses, this project has also been looking at smaller locales. One of five major staging areas for migrants moving overland from Mexico into Arizona rests between El Tortugo and Sasábe, Sonora. Migrants leaving this area follow one of two main routes: north through the Altar Valley; or west and then north through the Baboquivari Valley. Because of the shared point of origin, Humane Borders has always

approached these two valleys as a single travel corridor. Consequently, analysis extents for the Sasabe Corridor encompass both valleys (Figure 13).

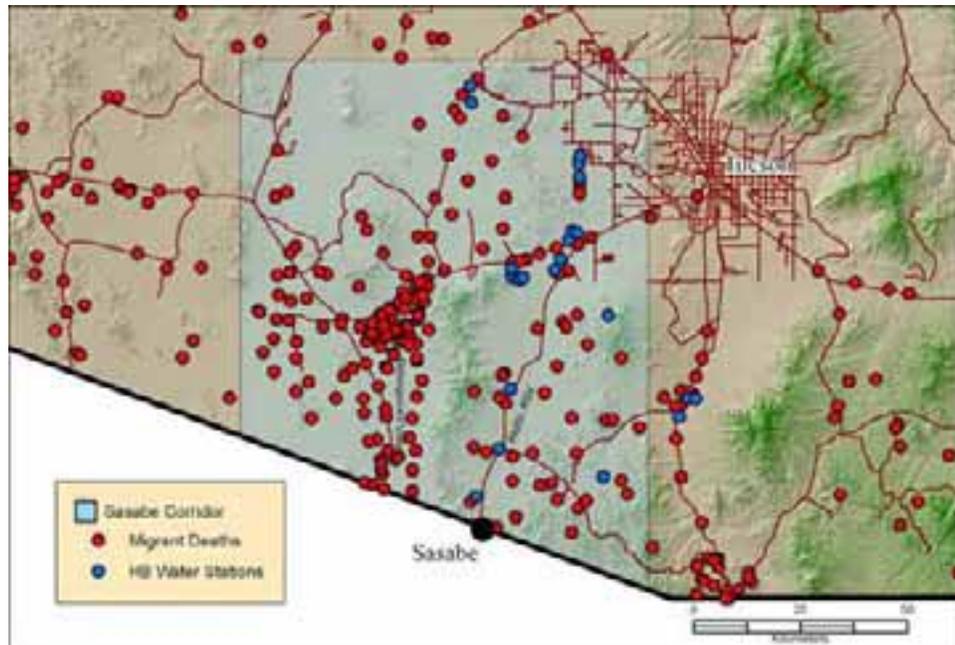


Figure 13: Map of the Sasabe Corridor showing migrant deaths and water stations.

For the following analyses, the same data sets used for the southern Arizona region (above) will be used, but restricted to the Sasabe Corridor. Within this area, a total of 207 deaths were recorded by the Border Patrol between 2000 and 2004. Cause of death varied between exposure (139), accident (19), homicide (3), confined space (2), previous medical condition (1), and undetermined causes (43). In the following analyses only deaths by exposure were considered. Roads, drainages, and water station feature classes were used, along with the 542 random sample points that fell within the corridor.

An important difference between the two valleys that make up the Sasabe Corridor is land ownership. The Altar Valley is a mix of public and private lands, primarily State Trust and the Buenos Aires National Wildlife Refuge. The Baboquivari Valley has a few, very small private inholdings but is almost entirely part of the Tohono O’odham Nation. Management policies for illegal immigrants differ markedly from one valley to the next. Tohono O’odham tribal members believe the best way to discourage migrants is to offer as little aid as possible.

Consequently, there are no water tanks or cell towers in the Baboquivari Valley, although they have allowed six warning beacons, five of which are in the Sasabe Corridor. In the Altar Valley, management policies change from owner to owner, which has allowed for the placement of water tanks, beacons, and cell towers.

The outcome of these policies, as well as the differing nature of the landscape in the two valleys has led to different consequences for illegal migrants. Of the 139 deaths by exposure in the Sasabe Corridor, 33 lay in the Altar Valley and 106 in the Baboquivari. The different ownership and management policies within this corridor make it a good place to look at the relationship between migrant deaths and the same natural and cultural features.

Death and Borders, Roads, and Drainages

Analyses of the relationship between migrant deaths and the international border, roads, and drainages were conducted in the same manner noted above, but restricted to the Sasabe Corridor. Using the 139 deaths by exposure, the KS test required a difference between samples of 0.1154 to reach statistical significance at the 5% level. In each of these three analyses, that hurdle was cleared and relationships between migrant deaths and the border, roads, and drainages were all significant. Table 1 summarizes the KS results for the Sasabe Corridor.

Table 1: Kolmogorov Smirnov Test Statistics and Probabilities

Relationship	KS Score	Probability
Deaths and the Border	0.295	0.000
Deaths and Roads	0.138	0.030
Deaths and Drainages	0.150	0.014

The cumulative proportion graphs for roads and drainages also show a similarity in pattern to that found in the southern Arizona region. That is, in each graph (Figures 14 and 15) the death by exposure line was located to the left of the random sample line. This tells us that deaths are more likely to occur near roads and drainages, indicating their importance in the Sasabe corridor as migration routes.

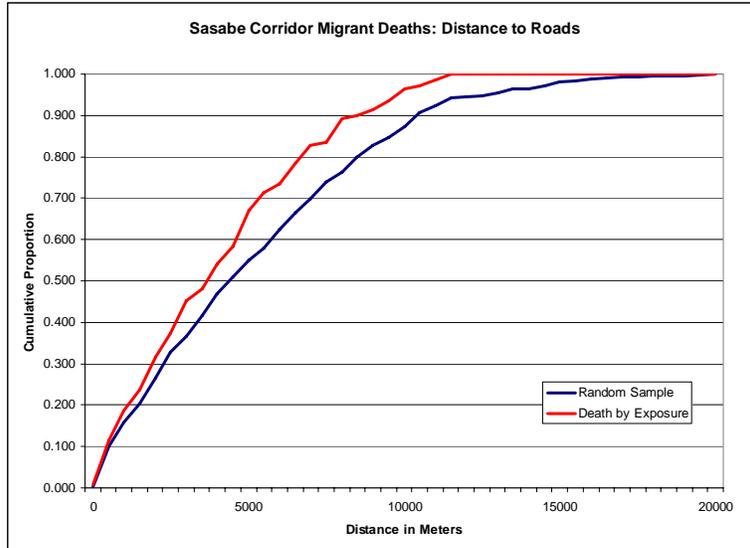


Figure 14: Distance to Roads: Cumulative Proportions for death by exposure and random sample in the Sasabe Corridor

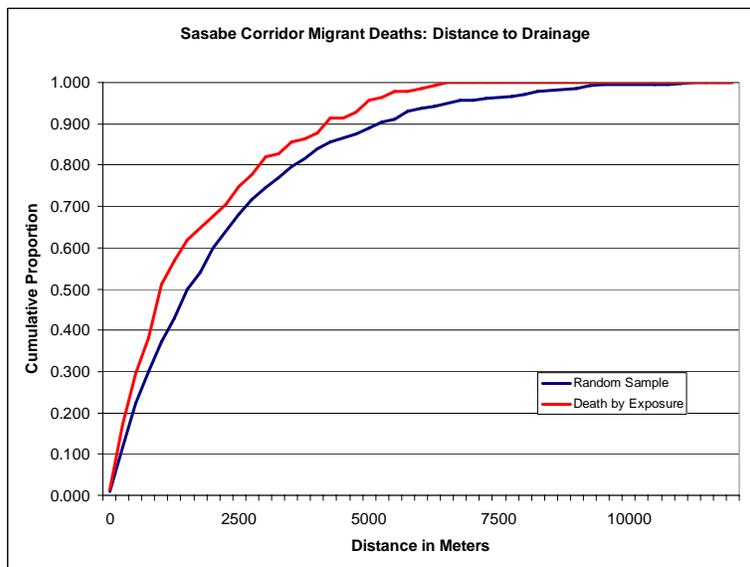


Figure 15: Distance to Drainages: Cumulative Proportions for death by exposure and random sample in the Sasabe Corridor

Of particular interest was the distance to border graph (Figure 16). Here the death and random sample lines are nearly identical until the 30 kilometer mark, where the death by exposure line rises sharply. In fact, 50% of all migrant deaths in the Sasabe Corridor occur between 30 and 50 kilometers. Looking at the map (Figure 13) this distance corresponds to the large cluster of deaths in the Baboquivari Valley. Most of these deaths occurred prior to 2004 and 2005. Once the pattern was recognized, local sources indicate that both enforcement efforts

proportion graph, Figure 17, shows the death line to the right of the random sample line. This indicates that in the Sasabe corridor deaths are occurring farther from the tanks than would be expected if the pattern was random.

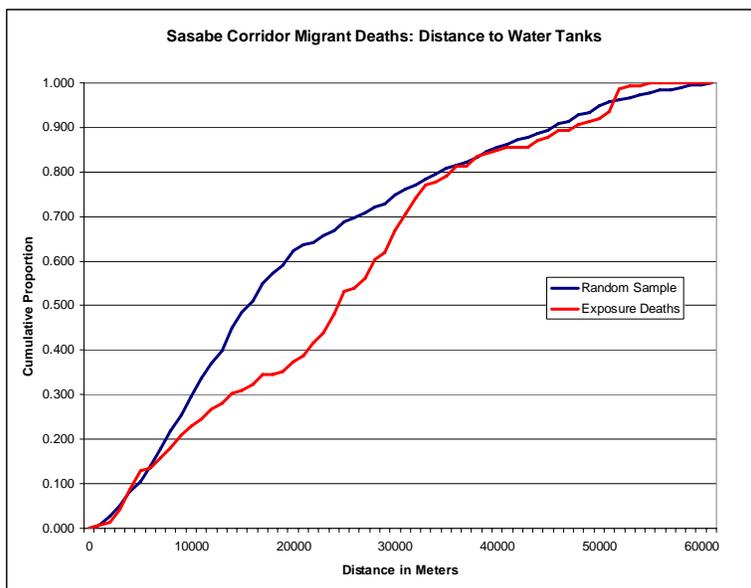


Figure 17: Distance to water stations: cumulative Proportions for death by exposure and random sample in the Sasabe Corridor

This is an indication that the Humane Border tanks have had an effect in this area, but given the data available it is not possible to say that they are the sole, or even the primary reason for this pattern. Because there are no tanks in the Baboquivari Valley – and because there are a larger number of deaths there – distances to water stations only tell part of the story. We would probably get a similar distribution if we looked at the Sasabe Corridor deaths in relation to Highway 86, the main road through the Altar Valley and the spine along which most of the water stations are distributed; and nobody would suggest that the highway is the main reason for reduced deaths. At this point, it is also unsatisfactory to limit the analysis to the Altar Valley because the number of deaths there is so small it is difficult to get reasonable test statistics. Instead, these results should be viewed as an encouraging sign of the effectiveness of the tanks at helping to prevent deaths, but also as something that requires further study.

Future Research Directions

The analyses presented here are only the beginning of what Humane Borders hopes to do with these data, and we have already begun working on additional questions and problems. In the next year we will record GPS coordinates for all Humane Border tanks so that we can do a more thorough analysis of their effectiveness at preventing deaths. We are also beginning to explore path distance, rather than Euclidean distance models. It is likely that path distance models would change the results of the analyses presented here. Path distance models will also allow for the discovery of travel corridors which, along with viewshed models of flag positions, would help Humane Borders more effectively position water stations. Finally, using backlink grids, path distance models could be used to backtrack from death locations to the border, allowing better targeting of prevention and education efforts.

In addition to these analytical efforts, we need more data. By establishing water stations on tracts of land managed by agencies that currently do not cooperate with Humane Borders, we could more effectively assess the value of our stations in saving lives. However, such assessments will not be possible without timely and complete data concerning migrant deaths. We welcome the cooperation of all government agencies concerned with these questions and would also encourage these agencies to establish more consistent contacts with one another.

Summary and Conclusions

If, as we note in the introduction, 12 million people have entered the country illegally, it is likely that slightly fewer than 500,000 people cross the southern border in a given recent year. Not unlike many natural features in the Desert Southwest, the scale of this migration defies the imagination. There are no easy answers to the crisis, either on the border, or in America's interior where our economy now depends on migrants to do jobs others will not take (Paral 2005). Given the complexity of the problem and the size of the migration, it is tempting to overlook the more than 2,200 people who have died thus far and hope the Border Patrol's strategy of enforcement and deterrence will begin to lower death rates.

While some aspects of the Border Patrol's strategies may be having success, there are many reasons to avoid this temptation. The most obvious, of course, is the God-given humanity and dignity of each migrant that is now deceased. Additionally, continuing increases in death rates call into question the long-term sustainability of a deterrence-based approach. Finally, data from the above analysis suggests there are probably many more deceased migrants still lying undiscovered in the desert. Without questioning the outstanding integrity or intent of Border Patrol agents, it is *necessary* to question the wisdom of current border policies.

In this paper, we have presented the mission and goals of Humane Borders, the most important of which is the saving of lives by maintaining water stations in the desert. We have also presented a good faith effort to assess our effectiveness in fulfilling our mission. Thus far, the results are equivocal, but we are hopeful that preliminary signs of success will be borne out by further analysis. At the very least, we understand a good deal more about the relationships between the distribution of deaths and structure of the natural and human environment.

In their 1994 National Strategy document, the Border Patrol (1994:5) discusses the need for "valid measures of effectiveness of border control mechanisms" and calls into question the validity of apprehension rates as a measure of success (Border Patrol 1994:7). As noted above, this same document also singles out declining death rates among illegal migrants as an indicator of success. This contradiction between the purported need for valid measures of success and an apparent unwillingness to acknowledge, discuss, or provide timely information concerning a phenomenon that may very well serve as such a measure is puzzling – especially when the measure in question revolves around an issue as serious as the loss of human life.

At Humane Borders, we incorporate GIS into our existing practices of openness and transparency. We hope to lead by example. Our practices, applied more broadly, can lead to solutions for the border crisis that are more effective than those tied up in ideologically driven polemics or policy assumptions. In struggling to better understand the migrant death crisis, we seek to join all interested parties in the community and government in finding better solutions.

Acknowledgements

We are deeply indebted to the thousands of volunteers who have driven trucks, cleaned trucks, helped repair trucks, replenish truck supplies, picked up trash, entered water consumption data and generally helped keep Humane Borders moving forward. We are thankful to those who share the leadership of Humane Borders, including, among others, Sue Ann Goodman, Tim Holt, Sister Elizabeth Ohmann, and Paul Fuscini. We are also grateful to other members of the Spatial Research Group at Humane Borders, including Alona Bachi, Bethany DeBorde, Raymond Duakei, and Bill McHugh. John Chamblee gratefully acknowledges the the insights he received from discussions with Rocio Magaña of the University of Chicago and Bruce Anderson of the Pima County Medical Examiner's office. Thanks also to Ryan Seidel, who downloaded lots and lots of DEMs.

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Author Information

John F. Chamblee

Department of Anthropology

[The University of Arizona](#)

Tucson, AZ 85721

chamblee@u.arizona.edu

Gary L. Christopherson

Director, [Center for Applied Spatial Analysis](#)

Harvill Building 460

[The University of Arizona](#)

Tucson, AZ 85721

garych@casa.arizona.edu

Mark Townley

President, Humane Borders

www.humaneborders.org

mark.townley@gmail.com

Daniel DeBorde

Peace Corps Worker

thedeordes@peacemail.com

Robin Hoover

Founder and Media Spokesperson, Humane Borders

Pastor, Tucson First Christian Church

www.humaneborders.org

rhoover@gainusa.com