MEETING NOTICE AND AGENDA

COMMITTEE ON BINATIONAL REGIONAL OPPORTUNITIES (COBRO)

The Committee on Binational Regional Opportunities (COBRO) may take action on any item appearing on this agenda.

Tuesday, October 7, 2008

3:00 to 4:30 p.m.

SANDAG, 7th Floor Conference Room
401 B Street, Suite 800
San Diego, CA 92101-4231

Staff Contact: Hector Vanegas
(619) 699-1972
hva@sandag.org

AGENDA HIGHLIGHTS

- PRESENTATION ON THE U.S. ENVIRONMENTAL PROTECTION AGENCY’S TRUCK STOP ELECTRIFICATION STUDY
- BORDER CROSSING VEHICLE AIR MONITORING STUDY UPDATE
- REPORT ON LAND USE TRANSITIONS IN THE TIJUANA RIVER WATERSHED

MISSION STATEMENT

The Committee on Binational Regional Opportunities (COBRO) will advise the Borders Committee of the San Diego Association of Governments (SANDAG) concerning both short- and long-term binational related activities, issues, and actions; provide input regarding binational border-related planning and development; and identify ways to assist and coordinate with existing efforts in the binational area. The COBRO will serve as a working group to the SANDAG Borders Committee to facilitate a better understanding of the binational border-related issues and needs of the California-Baja California region.
Welcome to SANDAG! Members of the public may speak to the COBRO on any item at the time that the Committee is considering the item. Please complete a Speaker’s Slip which is located in the rear of the room and then present the slip to Committee staff. Also, members of the public are invited to address the Committee on any issue under the agenda item entitled Public Comments/Communications. Speakers are limited to three minutes. The COBRO may take action on any item appearing on the agenda.

This agenda and related staff reports can be accessed at www.sandag.org under meetings on SANDAG’s Web site. Public comments regarding the agenda can be forwarded to SANDAG via the e-mail comment form also available on the Web site. E-mail comments should be received no later than noon, two days prior to the COBRO meeting.

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ITEM # | RECOMMENDATION
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1. WELCOME AND INTRODUCTIONS |  

+2. COMMITTEE ON BINATIONAL REGIONAL OPPORTUNITIES (COBRO) MEETING SUMMARY OF SEPTEMBER 2, 2008 | APPROVE

Meeting summary of September 2, 2008.

3. PUBLIC COMMENTS/COMMUNICATIONS AND MEMBER COMMENTS | INFORMATION

Each speaker is limited to three minutes.

**CONSENT ITEM (#4)**

+4. UPCOMING EVENTS | INFORMATION

**REPORT ITEMS (#5 through #8)**

5. NEW STRATEGIES TO FACILITATE UPCOMING VISA RENEWALS IN TJUANA (Amy Radetsky, United States Consulate General in Tijuana, Mexico) | INFORMATION

The U.S. Consulate General in Tijuana will brief the Committee on its new program to process the anticipated visa renewal applications.

+6. PRESENTATION ON THE U.S. ENVIRONMENTAL PROTECTION AGENCY’S (EPA) TRUCK STOP ELECTRIFICATION STUDY (Dave Fege, U.S. EPA) | INFORMATION

This report will focus on the U.S. EPA’s Truck Stop Electrification (TSE) study which evaluates the concept of TSE services at international Ports of Entry. TSE technologies, which have been successfully applied in the U.S., allow drivers to turn off their engines and hook up to electrical power supplies and communications connections for air conditioning and other services to reduce idling.
<table>
<thead>
<tr>
<th>ITEM #</th>
<th>RECOMMENDATION</th>
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<tr>
<td>+7.</td>
<td>BORDER CROSSING VEHICLE AIR MONITORING STUDY UPDATE (Jenny Quintana, Ph.D., San Diego State University)</td>
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<td>This presentation will report the findings from the Border Crossing Vehicle Air Monitoring Study. The study involved using an air quality monitor that records the level of particulate matter in private vehicles that crossed through regular private vehicle and SENTRI lanes at the Otay Mesa and San Ysidro Ports of Entry. Approximately 100 vehicles were monitored in this study.</td>
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<td>+8.</td>
<td>REPORT ON LAND USE TRANSITIONS IN THE TJUANA RIVER WATERSHED (Lina Ojeda, El Colegio de la Frontera Norte)</td>
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<td>This report examines how within the U.S. and Mexico, different economic and social factors trigger land use change. These factors hamper goals that would integrate planning and management of binational basins and shared water resources.</td>
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<td>9.</td>
<td>NEXT MEETING DATE AND LOCATION</td>
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<td>The next COBRO meeting will be on Tuesday, November 4, 2008, from 3:00 to 4:30 p.m., at SANDAG.</td>
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+ next to an item indicates an attachment
COMMITTEE ON BINATIONAL REGIONAL OPPORTUNITIES (COBRO)
MEETING SUMMARY OF SEPTEMBER 2, 2008

1. WELCOME AND INTRODUCTIONS

The September 2, 2008, Committee on Binational Regional Opportunities (COBRO) meeting was called to order by Chair Paul Ganster. The meeting was held at SANDAG.

Members present were: Chair Paul Ganster, Institute for Regional Studies of the Californias; Vice-Chair Cindy Gompper-Graves, South County Economic Development Council; Past Chair Elsa Saxod, Saxod Enterprises; Elvira Felix, Consulate General of Mexico in San Diego; Sergio Pallares, Caltrans; Alicia Scolari and Ivy Cervantes Cruz, State of Baja California; Gary Brown, City of Imperial Beach; Alberto Morghen and Carlos Cañedo, City of Tecate; Lorena Flores, City of Tijuana; Megan Jones, County of San Diego; Arturo Montfort, Desarrollo Económico e Industrial de Tijuana (DEITAC); Tito Alegria, El Colegio de la Frontera Norte (COLEF); Yolanda Walther-Meade, Fundación Internacional de la Comunidad, A.C.; Alonso Hernandez, Instituto Municipal de Planeación de Tijuana (IMPlan); Nathan Owens, San Diego Dialogue; Angelika Villagrana, San Diego Regional Chamber of Commerce; Thomas Currie and Jason Wells, San Ysidro Chamber of Commerce; Clay Phillips, Tijuana River National Estuarine Research Reserve (TRNERR); and Toby Sosbee, U.S. Customs and Border Protection.

Advisory members present were: Amy Radetsky, Consulate General of the United States in Tijuana; and Angelica Suarez, Southwestern College.

SANDAG staff members present were: Elisa Arias, Héctor Vanegas, Ron Saenz, and Marianne Veach.

2. MEETING SUMMARY

Angelika Villagrana, San Diego Regional Chamber of Commerce, entertained a motion to approve the August 5, 2008, meeting summary. Yolanda Walther-Meade, Fundación Internacional de la Comunidad, A.C., and Thomas Currie, San Ysidro Chamber of Commerce; seconded the motion. The meeting summary was approved.

3. PUBLIC COMMENTS/COMMUNICATIONS AND MEMBER COMMENTS

Toby Sosbee, U.S. Customs and Border Patrol, briefed the group on events on Sunday and Monday, August 31st and September 1st, Labor Day weekend. Customs and Border Protection carried out the test phase of the opening of lanes at the Otay Mesa commercial facility for passenger traffic. As successful tests were already done, they wanted to try it on a busier weekend like Labor Day
weekend. Although, there were some difficulties in contacting the City of Tijuana’s Municipal Police to assist in directing traffic into the open lanes, the test was seen as successful. Within a two-hour period on Sunday, 217 cars were processed in these lanes and wait times were reduced from 40 minutes to 20 minutes. On Monday from 5:00 p.m. to 7:50 p.m., 490 cars were processed and wait times were less than 15 minutes. This test phase was seen as a success as it reduced wait times by more than half. These lanes will be used on weekends and significant holidays when high volume of traffic is expected. The frequency of use of these lanes is still undecided, but it is likely that it will soon be on a scheduled basis.

Olivia Maldonado, Secretary of Economy of Mexico, informed the committee of the Regional Forum of Competitiveness in the Northwest of Mexico, to be held in Tijuana on September 18, 2008. This event is to present the competitiveness index and methodology used to weigh the region’s cities in the areas of economics, socio-demographics, urban and institutional development. Ms. Maldonado offered to send electronic invitations to COBRO members.

Thomas Currie, San Ysidro Chamber of Commerce, expressed concern about the thousands of laser visas that will expire next year. His first concern is that there is not a facility in Mexicali to renew these visas. This means that all expired visa holders will have to travel to Tijuana to get them renewed. Jason Wells, San Ysidro Chamber of Commerce, stated that 70,000 laser visas will expire by the end of this year with another 120,000 expiring the following year. He proposes a temporary facility in Mexicali. The other concern expressed was that when renewing a laser visa, the visa holder has to surrender his or her visa for 30 days while the renewal process takes place. Mr. Currie pointed out that for some visa holders this means missing school or work for 30 days. The San Ysidro Chamber of Commerce proposes that there be a temporary visa issued while visa holders are waiting for their permanent renewed visa.

Amy Radetsky, Consulate General of the United States in Tijuana, responded that in addition to the consulate in Tijuana there is an annex dedicated to renewing visas. This annex was built in expectation of the surge of renewals next year. Building a facility in Mexicali is not possible due to logistical issues. She added that the 30-day wait period for renewed visas is a logistical issue. She will ask for more information from experts in the area and will report back at the next meeting.

Angelika Villagrana, San Diego Regional Chamber of Commerce, said that she would make it an agenda item when her group visits Washington, DC.

On October 8, 2008, San Diego Dialogue and the Mexico Business Center will be hosting the Forum Fronterizo. Bill Richardson, Governor of New Mexico, will be a potential speaker on renewable energy on the border. Other solar and renewable energy providers in the San Diego/Imperial/Baja California Region have also been invited to speak. An electronic invitation will be sent to everyone on the San Diego Dialogue list serve.

4. UPCOMING EVENTS

Chair Paul Ganster requested that any upcoming events be sent to Ron Saenz and Hector Vanegas, SANDAG.
Mr. Wells, San Ysidro Chamber of Commerce, announced that on September 19th the San Ysidro Chamber of Commerce is holding a Casino Night as a fundraiser for the Chamber and the Business Association. All are welcome to attend.

5. SANDAG’s BINATIONAL SEMINAR TASK FORCE RECOMMENDATIONS

Chair Paul Ganster and Hector Vanegas, SANDAG, reported on the binational seminar task force recommendations to be presented to the Borders Committee at their next meeting.

The first recommendation is to “explore the feasibility of developing a regional transportation infrastructure map that would include the regional transportation projects of the San Diego Region and the Municipality of Tijuana through 2010.” There was discussion about what is meant by regional infrastructure. Hector Vanegas, SANDAG, mentioned that this recommendation includes transportation infrastructure projects on both sides of the border.

The second recommendation is to “explore the feasibility of developing mapping of existing and planned water, sewer, energy, natural gas, and electrical infrastructure in the San Diego/Tijuana region.”

The third recommendation is to “evaluate coordination with the appropriate agencies on both sides of the border to investigate and gather existing baseline data on greenhouse gas (GHG) emissions in the San Diego/Tijuana Region and corresponding target reductions. If baseline data on GHG emissions can be gathered by sector, create a graphic of the San Diego/Tijuana Region carbon footprint. (Sectors may be defined as transportation, electricity, industrial, natural gas end uses, agriculture, and other waste).” Chair Paul Ganster added that both Baja California and California are moving quickly on calculating GHG emissions.

The fourth is to “proceed with the appropriate arrangements for SANDAG to accept IMPlan’s invitation to become its permanent advisory member on its Advisory Board.” Paul Ganster expressed that he thinks this a good step in formalizing the relationship between the two agencies.

The fifth recommendation indicates “when the Otay Mesa – Mesa de Otay Binational Corridor Strategic Plan is next updated, include a new action to incorporate coordination of Smart Growth and Climate Change planning efforts between the San Diego Region and Baja California.”

The final recommendation includes “exploring opportunities for COBRO members to invite practitioners to discuss best practices at borders around the world in order to evaluate San Diego/Tijuana border crossings.”

Jason Wells, San Ysidro Chamber of Commerce, reported that Senator Ducheny’s office would be supportive of these and suggested that her office may also consider providing assistance for the mapping project.

Jason Wells, San Ysidro Chamber of Commerce, made the motion to accept the recommendations made by the task force. Angelika Villagrana, San Diego Regional Chamber of Commerce, and Thomas Currie, San Ysidro Chamber of Commerce, seconded the motion. The motion was approved.
Sergio Pallares, Caltrans, reported on the Border Governors Conference held in Hollywood, California from August 13 to August 15, 2008. There were three handouts distributed. The first being the Joint Declaration which includes the signatures of all ten border governors and their representatives, the second is a matrix which explains the summary worktable progress report and the third is a matrix showing the schedule of implementation of the recommendations.

Mr. Pallares gave a brief overview of the structure of the conference explaining that there are different worktables under each governor that make recommendations to improve the border region. Each worktable covers a different area including: Agriculture, Border Security, Logistics and International Crossings, Economic Development, Education, Emergency, Energy, Environment, Health, Science, Tourism, Water, and Wildlife. These recommendations are included in the Joint Declaration. The Joint Declaration is made up of three sections: the Preamble, the Specific Recommendations (from the 13 worktables), and the Addendum. The Addendum includes items that do not fall under a topic of a specific worktable, but that a governor wants discussed.

Last year, it was indicated that Caltrans had been representing the State of California, but that COBRO did not have a voice. In response to this, Caltrans is extending an invitation to COBRO to provide input in order to be brought to the worktable next year. He asked COBRO to develop the process to provide this input.

There was discussion on how to initiate the process to give input on recommendations. Mr. Pallares indicated that he would make contact information for each worktable head available. He also added that Caltrans’ invitation is extended for contributions to the Logistics and Border Crossing worktable.

Mr. Pallares also indicated that recommendations do not get reflected in the Joint Declaration without consensus of all the governors. If the implementation of a recommendation is to take place within one state, then that state is responsible to bring it to fruition.

The next meeting will be in Monterrey, Nuevo Leon, Mexico, and in two years it will be held in Arizona.

There was further discussion on other parts of the conference including the sections on human trafficking moderated by Maria Shriver and economic development.

All of the speeches are posted on the Border Governors Conference Web site.

7. REPORT ON THE TIJUANA MUNICIPAL URBAN DEVELOPMENT PLAN

Alonso Hernández, Sub-Director of IMPlan, reported on the Tijuana Municipal Urban Development Plan. The plan was last updated 21 years ago. Several public hearings were held: one in March with stakeholders from the Autonomous University of Baja California (UABC) and two other hearings with the Tijuana City Council’s Urban Planning Subcommittee. IMPlan is now in the process of preparing to present it to the entire City Council. Once the City Council approves the plan, it will be presented to the State of Baja California.
The plan includes three chapters: urban development, environment, and quality of life. These three chapters are based on five strategies: the region as a metropolitan area, environment, competitiveness, urban development, and administration of development. From these three sections and five strategies 70 different themes and programs were developed. Each theme or plan has an identified stakeholder and a timeline.

Another aspect of the Municipal Urban Development Plan considers the Tijuana region as a binational metropolitan region. This aspect of the plan will include establishing a formal regional agency in order to gain access to different funds that are available. To continue their work they are also starting an urban development plan for the population center.

Clay Phillips, TRNERR, raised discussion about the Los Laureles Specific Plan. Mr. Hernandez indicated that under the Municipal Urban Development Plan no modifications will be made to Los Laureles. In the development plan involving the population center, Los Laureles will be included.

Ron Saenz, SANDAG, highlighted that Tijuana’s Municipal Urban Development Plan is the first one that has been done since 1981. It is also the first one that adopts strategies from the Otay Mesa - Mesa de Otay Strategic Plan. Additionally, it establishes a technical committee with SANDAG. It also identifies strategies for global climate change and for conservation in line with the Las Californias plan.

Tito Alegria, COLEF, pointed out that there was a similar urban development strategic plan done seven years ago by the previous administration in Tijuana and the private sector. He also raised the water quality issue that the proposed Valle de las Palmas presents since runoff from this area would drain into the Abelardo Rodriguez Reservoir. He reported that when people settle in the new Valle Las Palmas development, 250,000 cars, many of which will leak oil, will be added to the area and that the risk of runoff that will contaminate the water supply is high.

Mr. Hernandez responded that Valle Las Palmas has been one of the most studied areas in the region. This project is included in the specific plan and IMPlan will continue to follow up with these issues. This is a long-term development plan and redirecting water away from the arroyo is included in the first phase.

Alberto Morghen, City of Tecate, added that Tecate has been working jointly with IMPlan to harmonize efforts in the area of a regional metropolitan area. Last week members of the Mexican Congress visited Tecate to learn about these efforts towards creating the Tijuana-Tecate-Rosarito metropolitan zone additional to the current existing seven metropolitan zones in Mexico. This new classification as a metropolitan zone will bring additional resources to their budget that can help with urban facilities and transportation infrastructure which will be the first time these decisions will be made on a more local level. Mr. Morghen offered to give a report on Tecate’s efforts, new policies (specifically renewable energy policy) and projects at a future meeting.

8. NEXT MEETING DATE AND LOCATION

The next COBRO meeting will be on Tuesday, October 7, 2008, from 3:00 to 4:30 p.m., at SANDAG.
| WHAT: | Transborder Institute (TBI) at the University of San Diego  
|       | Enrique Morones, Border Angels  
| WHEN: | October 7, 2008  
| WHERE: | UC Forum A & B at USD  
| MORE INFO: | http://www.sandiego.edu/tbi/events/tbi_usd.php  

| WHAT: | San Diego Regional Chamber of Commerce / San Diego Dialogue  
|       | 7th Annual Mexico Economic Outlook & 22nd Forum Fronterizo  
| WHEN: | October 8, 2008  
| WHERE: | Sheraton San Diego Hotel & Marina  
| MORE INFO: | http://www.sdchamber.org/index.html  

| WHAT: | Center for U.S.-Mexican Studies at UCSD  
|       | Germán Palafox Palafox - “Mexico’s Policies for Poverty Reduction”  
| WHEN: | October 8, 2008  
| WHERE: | UCSD’s Institute of the Americas Complex - Weaver Center  
| MORE INFO: | http://usmex.ucsd.edu/  

| WHAT: | SEDECO Baja California - U.S. Department of Commerce  
|       | BajaMak Expo Industrial  
| WHEN: | October 9, 2008  
| WHERE: | Valle Bonito Industrial Park, Tijuana B.C., Mexico  
| MORE INFO: | info@bajamak.com or www.bajamak.com  

| WHAT: | South County Economic Development Council  
|       | Fourth Annual South County Reception - Elected Officials Reception  
| WHEN: | October 9, 2008  
| WHERE: | Pier Plaza, Imperial Beach  
| MORE INFO: | http://www.sandiegosouth.com/  

| WHAT: | Transborder Institute (TBI) at the University of San Diego  
|       | Cardinal Theodore E. McCarrick, Reflections on Justice for Immigrants  
| WHEN: | October 13, 2008  
| WHERE: | Joan B. Kroc Institute for Peace and Justice at USD  
| MORE INFO: | http://www.sandiego.edu/tbi/events/regional.php  

UPCOMING EVENTS
WHAT: Center for U.S. - Mexican Studies at UCSD  
Douglas Massey - “Understanding America's Immigration Crisis”  
WHEN: October 15, 2008  
WHERE: UCSD’s Institute of the Americas Complex - Weaver Center  
MORE INFO: http://usmex.ucsd.edu/  

WHAT: Transborder Institute (TBI) at the University of San Diego  
Políticas inmigratorias actuales de la Unión Europea  
WHEN: October 20, 2008  
WHERE: Joan B. Kroc building, Room 253 at USD  
MORE INFO: http://www.sandiego.edu/tbi/events/tbi_usd.php  

WHAT: Center for U.S. - Mexican Studies at UCSD  
Gabriela Torres Mazuera - “The Ayuntamiento Rise and the Ejido Fall. Sociopolitical Reconfiguration of Decentralized Mexican Rural Space”  
WHEN: October 22, 2008  
WHERE: UCSD’s Institute of the Americas Complex - Deutz Room  
MORE INFO: http://usmex.ucsd.edu/  

WHAT: U.S. Environmental Protection Agency  
Border Energy Forum XV  
WHEN: October 23 - October 24, 2008  
WHERE: Monterrey, Nuevo León, Mexico  
MORE INFO: http://www.glo.state.tx.us/energy/border/forum/15/index.html  

WHAT: San Diego Hispanic Chamber of Commerce  
2nd Annual Hispanic Chamber Golf Classic: El Clásico  
WHEN: November 7, 2008  
WHERE: Maderas Golf Club, Poway, CA  
MORE INFO: edaniel@sdchcc.com or 619-702-0790  

WHAT: Institute of the Americas (IOA) at UCSD  
25th Anniversary Celebration - Latin America: The Next 25 Years  
WHEN: November 15, 2008  
WHERE: Institute of the Americas Plaza at UCSD  
MORE INFO: Sherry White Sherry@iamericas.org or http://www.iamericas.org/  

WHAT: Transborder Institute (TBI) at the University of San Diego  
Book Presentation: Mica chueca. Novela para la plebada inmigrante  
WHEN: November 19, 2008  
WHERE: Joan B. Kroc building, Room 253 at USD  
MORE INFO: http://www.sandiego.edu/tbi/events/tbi_usd.php  

WHAT: Institute of the Americas (IOA) at UCSD  
Baja California Masters Art Exhibit  
WHEN: November 20, 2008  
WHERE: Weaver Center at UCSD  
MORE INFO: edaniel@sdchcc.com or 619-702-0790  

Key Staff Contact: Hector Vanegas, (619) 699-1972; hva@sandag.org
PRESENTATION ON THE U.S. ENVIRONMENTAL PROTECTION AGENCY’S (EPA) File Number 3006300 TRUCK STOP ELECTRIFICATION STUDY

Introduction

The U. S. Environmental Protection Agency (EPA) is currently conducting a Truck Stop Electrification (TSE) study to evaluate the concept of TSE services at international Ports of Entry (POEs). TSE technologies, which have been successfully applied in the U.S., allow drivers to turn off their engines and hook up to electrical power supplies and communications connections for air conditioning and other services to reduce idling.

Discussion

This study is evaluating how TSE technology could help cross border commercial vehicles reduce idling by shutting off their engines. Instead of idling in a line to cross the border, trucks would pull off to a TSE facility, shut off their engines and wait to cross the border at an appointed time. While waiting, they could take advantage of power supplies, communications, and other amenities at the TSE site. It is anticipated that implementing this concept could reduce idling and congestion and make the crossing process more predictable and efficient.

A potential application of a TSE facility in the San Diego/Tijuana border region could be for northbound trucks that cross at the Otay Mesa Commercial POE. Three thousand trucks cross per day through this facility in the northbound direction. At this POE, trucks face significant waits to pass through Mexican Customs inspection facilities, U.S. Customs and Border Protection security inspections, and California safety inspections before being allowed to legally enter into the United States.

The initial effort will address the following considerations through research and discussions with stakeholders to develop a more fully detailed concept for a border crossing TSE services at POEs:

- The need to link border crossing TSE to a notification/appointment system and the willingness of customs, security, and other stakeholders to consider such a system;
- The availability of land for a staging area that will accommodate the anticipated levels of use near the Otay Mesa POE and its cost;
- The availability of grants and other funds for land and infrastructure on the Mexico side of the border;
• The conditions under which a border crossing TSE would make commercial sense to TSE service companies;
• A financial and pricing structure that is feasible for trucking companies, particularly smaller drayage operations;
• Ownership (governmental or private) of the staging area; and
• Buy in from the trucking community and potential incentives for cross-border truckers to use the staging area rather than staying in the queue.

Next Steps

U.S. EPA will hold additional discussions with entities that would be involved in the potential implementation of the TSE concept. A final concept paper will be developed that can lead to a more detailed feasibility study of incorporating a TSE facility to serve the Otay Mesa-Mesa de Otay area.

Also, SANDAG will continue to explore additional funding sources in order to build upon the EPA’s TSE study and advance SmartWay Transport goals. If funding becomes available, a feasibility study would be conducted to assess the viability of implementing TSE facilities serving the existing Otay Mesa Commercial POE and the future Otay Mesa East POE.

Staff will provide COBRO members with updates on any progress made on these efforts.


Key Staff Contact: Ron Saenz, (619) 699-1922; rsa@sandag.org
Truck Stop Electrification: A Strategy to Reduce Emissions and Save Money at Border Crossings
Contact: Tom Beierle, Ross & Associates, (206) 328-4739, tom.beierle@ross-assoc.com

At International Ports of Entry between Mexico and the United States, trucks face significant wait times to cross the border. While they wait, their idling engines emit air pollution, which damages the health of drivers, workers, and nearby communities. They also burn valuable diesel fuel, which wastes money. In addition, congestion burdens local traffic circulation and constrains the region’s economic growth.

Truck stop electrification (TSE) at border crossings is a promising solution that can reduce emissions and save money. TSE technologies, which have been successfully applied in the U.S., allow drivers to turn off their engines and hook up to electrical power supplies and communications connections for air conditioning and other services. When drivers use TSE, they can turn off their trucks while waiting and save money and the environment.

At border crossings, TSE technology could be used to reduce idling, reduce congestion, and make the crossing process more predictable and efficient. Instead of idling in a line to cross the border, trucks would pull off to a TSE facility, shut off their engines and wait to cross the border at an appointed time. While waiting, they could take advantage of power supplies, communications, and other amenities.

The feasibility of a TSE facility for northbound trucks at the Otay Mesa Port of Entry is currently being studied. Three thousand trucks cross per day from Mexico into the U.S. at Otay Mesa. A TSE facility could be located before trucks enter the Mexico export facility (location N1 in the figure) or before they enter the U.S. import facility (location N3 in the figure).
Key Facts

- A recent study by SANDAG, in partnership with Caltrans (SANDAG, 2006), estimated that border crossing delays cost the California economy $3.9 billion in lost output in 2007 and more than 43,000 jobs. If no steps are taken to reduce delays, the study predicted, these losses would more than double in the next ten years.
- Based on U.S. EPA data, SANDAG estimates that a border crossing TSE facility has the potential to conserve 1.5 million gallons of diesel fuel annually.
- At a typical TSE service fee of $1.00-$2.00 per hour, compared to roughly $4.00 for a gallon of diesel, every hour that drivers use a TSE service rather than idling saves $2.00-$3.00 plus another 0.50-0.95 cents an hour on maintenance.
- Each gallon of diesel consumed results in 22.2 lbs of CO2 released into the atmosphere. Diesel emissions have been linked to asthma, and they include over 40 cancer-causing substances that lead to other illnesses.
- Based on California Energy Commission emissions data and average truck waits at the border, SANDAG estimates that TSE facilities on the Mexican side of the Otay Mesa POE have the potential to reduce 3.7 million tons of NOx and 15.7 million tons of CO2 annually.
- According to SANDAG (2006), trucks at Otay Mesa typically wait an average of 2 hours per crossing. Anecdotal information from truckers suggests that waits can sometimes be up to 6 hours.
- A 2004 CalTrans study concluded that, at Otay Mesa, “commercial vehicle volumes are consistently congested all day from 0600 to 1800 northbound and southbound, especially notable during the midday hour and before the port closes for the day.” At maximum congestion, the study reported 150 trucks in the northbound queue in Mexico alone.

Key Questions

- Where should the TSE facility be located?
- To what extent should the TSE be integrated into POE customs processes?
- How would the TSE be financed?
- What incentives and disincentives would drivers have to use the facility?
A status report on the Border Crossing Vehicle Air Monitoring Study was last presented at the October 2, 2007, COBRO meeting. This study measured air pollution exposure in private vehicles that cross through regular private vehicle and SENTRI lanes at the San Ysidro and Otay Mesa Ports of Entry.

Dr. Jenny Quintana, Associate Professor of Environmental Health at San Diego State University (SDSU), heads the project with assistance of Dr. Adriana Vargas, School of Medicine, and Dr. Guillermo Ventura, Department of Chemistry from the Autonomous University of Baja California (UABC) campus in Tijuana. Dr. Quintana will present findings from the study at the meeting.

Key Staff Contact: Ron Saenz, (619) 699-1922; rsa@sandag.org
REPORT ON LAND USE TRANSITIONS IN THE TIJUANA RIVER WATERSHED  File Number 3003200

This report examines how within each country different economic and social factors trigger land use change. These factors hamper goals that would integrate planning and management of binational basins and shared water resources. The Tijuana River Watershed is the focus of this report.

Attachment: 1. Land-cover/use transitions in the binational Tijuana River watershed during a period of rapid industrialization, Ojeda; Bocco; Ezcurra; & Espejel, 2008

Key Staff Contact: Hector Vanegas, (619) 699-1972; hva@sandag.org
Land-cover/use transitions in the binational Tijuana River watershed during a period of rapid industrialization

Ojeda-Revah, L.1*; Bocco, G.2; Ezcurra, E.3 & Espejel, I.4

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Abstract

**Question:** How do differing social and economic systems affect the dynamics and trajectory of land cover / land use change on similar, neighbouring ecosystems in a time span when an economic industrialization program was enforced?

**Location:** Tijuana River watershed, located on the border between Baja California, Mexico and California, United States.

**Methods:** We quantified land use changes between 1970 and 1994 in the Tijuana River watershed. Using aerial photographs and geographic information systems, we elaborated land-cover/use maps and calculated transition probability matrices to describe natural land-cover changes at the landscape level on both sides of the border.

**Results:** Land cover / land use transitions are mainly driven by urban development on both sides of the border, but exhibit different patterns in each country. The processes seem to be more complex in the Mexican part of the basin, where itinerant land use may revert induced grasslands and rain-fed agriculture into natural communities, than on the US side, where the transition pathways are few and unidirectional.

**Conclusions:** Despite the need for an integrated planning and management of binational basins and shared water resources, in practice, these goals may be hampered by different economic and social factors triggering land use change within each country.

**Keywords:** Binational watershed; Geographic information systems; Mexico; Transition model; United States.

**Abbreviations:** GIS = Geographic information system; LUCC = Land cover and use change; TRW = Tijuana River watershed.

Introduction

The study of land cover and use change (LUCC) processes has become a major topic of environmental research (Houghton 1994; Lee et al. 1995). Its analysis has been based on the quantification of land use and its change over time, using different sources and techniques (Ojima et al. 1994; Lambin 1997). LUCC operates at the landscape level through ecosystem fragmentation, which disrupts environmental functions (Forman 1995; Mas et al. 2004). As semi-natural landscapes become predominant, knowledge of LUCC in human altered ecosystems will play a growing role in the conservation of natural resources (Noss 1996; Schwartz 1997).

In order to study LUCC patterns and processes, Bürgi et al. (2004) suggested the use of the driving forces concept, and identified five main types: natural, socioeconomic, policies, technology and cultural. They also considered that comparative studies on borders are useful to analyse the effects of regulations, subsidies and political systems and that selected periods must reflect a change in the conductive force potential level.

Binational watersheds are ideal study areas, because they may function as split-plots where most natural variables are similar, but where the contrasting economies and social dynamics may operate differently, imposing divergent pressures on shared natural resources. The study of LUCC patterns in watersheds is of particular relevance because it may affect erosion rates (Sah & Shimizu 1998), hydrologic cycles and water availability (Peters & Meybeck 2000).

At the border between Mexico and the United States, environmental research with a binational view has grown substantially during the past decade. Most environmental studies have been oriented towards water resources modelling and management (Frisvold & Caswell 2000; Brown 2003; Van Schoik et al. 2004; Cortés et al. 2005).
Binational geographic information systems (GIS) have been integrated in the Tijuana River watershed (Anon. 2005a) and in the Nogales Watershed (Brady et al. 2002). Other studies have dealt with urban growth and LUCC in Tijuana–San Diego (Herzog 1990) and Ciudad Juárez–El Paso (Peña et al. 2005), with watershed analysis in the San Pedro River Basin (Kepner et al. 2002, 2004; Miller et al. 2002). Mumme (2003) reviewed and analysed policy issues since the 1970s, and concluded that research topics such as natural resource conservation and LUCC deserve more attention.

Urbanization has not been considered a major cause of LUCC as it only accounts for 2% of the world’s land surface. In some areas, however, large-scale urbanization and extended peri-urban settlements fragment the landscapes and threaten ecosystem processes (Lambin et al. 2001). Although landscape pattern metrics have been applied to study urban morphology (Luck & Wu 2002; Cifaldi et al. 2004; Seto & Fragkias 2005), most spatial studies are applied to single cities (Jenerette & Wu 2001; Luck & Wu 2002; Herold et al. 2003) or several cities within one country. Physical processes of LUCC and socioeconomic processes that cause certain space configurations have been understudied (Seto & Fragkias 2005).

In this article we analyse LUCC patterns and transitions during the Border Industrialization Program (1970–1994) in the Tijuana River watershed (TRW), a binational basin on the Mexico-US border, bridging the states of California and Baja California (Fig. 1). We also examine the contrasting patterns observed north and south of the border, and analyse their main driving forces. This study follows previous research of the TRW bio-history (Ojeda & Espejel in press), in which the main historical events that shaped land cover / land use patterns and its change were identified. The study period we chose (1970–1994) coincides with the Border Industrialization Program started in Mexico in 1965 (Zenteno & Cruz 1992), which induced accelerated population and industrial growth within the basin, reaching a peak of 20% annual growth in industrial capacity between 1985-1990. Between 1970 and 1994, the number of ‘maquiladoras’ (tax-exempt assembly plants of foreign capital located on the Mexican side of the border) increased from 101 to 727. Shortly after 1994, the growth of the maquiladora industry started to dwindle, reaching negative values (−7%) in the 2000–2005 period (Anon. 2005b).

The main question we intended to explore with this study was how differing social and economic systems affect landscape patterns and LUCC in similar, neighbouring ecosystems, in that special time span when the economy of the region was oriented towards industrialization.

**Methods**

**Study area**

The TRW is located along the western border between Mexico and the US, covering 4450 km², of which almost 75% belong to Mexico (Fig. 1). Terrain is rolling to hilly, relief amplitude ranges from sea level to nearly 2000 m a.s.l. at its northeastern portion. It is part of the California Floristic Province, one of the world’s biodiversity hotspots (Myers et al. 2000). Within the basin, different varieties of mediterranean climate occur, characterized by mild winters and dry summers. Arid mediterranean climate dominates in the lowlands near the sea, where the mean annual rainfall is less than 200 mm and the mean annual temperature is 16 °C. In the highest sierras a more humid and cooler climate prevails, with yearly precipitation reaching 500 mm and mean annual temperature around 10 °C (Anon. 1995). Mixed conifer forest, juniper scrub, chaparral, coastal sage scrub, meadows and riparian land cover naturally inhabit the watershed. Land use (i.e. man-made) categories include urban development, grasslands, irrigated and rain-fed agriculture, and reservoirs (O’Leary 2005).

The watershed falls under the jurisdiction of San Diego County in the US, and the Municipalities of Tijuana and Tecate in Mexico. Population growth rates were 3.0% during the 1970s, and 4.8% in the 1980s and 1990s (3.1% between 2000 and 2005) in the Mexican municipalities (Anon. 2000, 2006a), and 3.2% in the 1970s, 2.9% in the 1980s, 1.2% in the 1990s (1.4% between 2000 and 2006) in San Diego County (Anon. 2006b). On both sides of the border only 1% of the population is related to primary production activities; in Mexico 41% work in the secondary sector (mainly industry) and 52% in services, while in the US 16% work in the secondary sector and 83% in services (Anon. 2000, 2006).

**Computing land cover change**

We worked with land cover / land use maps derived from black and white US Department of Agriculture 1970 Corona Satellite Photographs (1:20000) for the US part of the basin; black and white 1972 Instituto Nacional de Estadística Geografía e Informática aerial photographs (1:50000) for the Mexican side of the basin and Nation Oceanographic and Atmospheric Administration 1994 colour aerial photographs for the whole basin.

This study is part of a long-term research programme, which started in the 1930s and aims to monitor trends in LUCC in the basin. For comparison purposes, we adopted the land cover / land use classification developed by O’Leary (2005), combining categories that were not discernible in the oldest aerial photographs (Table 1).
Aerial photo-interpretation was carried out by means of a mirror stereoscope and using standard interpretation keys (tone, texture, pattern, shape and location of land cover / land use polygons as identified on the images) using the central portion of every photograph to avoid lateral distortion. Stereovision helped us to understand the relevant relationships between land cover and relief, and thus, to differentiate among visually similar cover types. Every interpreted photograph was manually digitized onto a common-base mosaic (scale 1:50000), and corrected using control points in a GIS. To ensure geometric consistency, the different layers were overlaid on a digitally enhanced 1994 SPOT panchromatic image (10 m spatial resolution) and checked thoroughly for consistency. The accuracy of polygon labelling was tested by verifying in the field at least 20% of the interpreted polygons, and corrections were made when needed.

The following landscape analyses were performed on the basis of patch number and area (Forman 1995): (1) area of each land cover \( S_i \); (2) number of patches in each land cover category \( N_i \); (3) perimeter shape ratio; i.e. total perimeter for the category \( P_i \) divided by the perimeter of a circle with the same area and equal to \( P_i / 2 \sqrt{(\pi S_i)} \) and (d) rate of change in land cover \[ C = (\log S_{i2} - \log S_{i1}) / (t_{2} - t_{1}) \], where \( S_{i2} \) is the area of land cover \( i \) at time 2, and \( S_{i1} \) is the area of the same land cover at time 1, \( t_{2} \) and \( t_{1} \) are the time dates. Rates of change were calculated both for the area of each land cover/use category and for the number of its patches, to respectively estimate expansion or retraction of different land cover / land use types, and their fragmentation.

**Table 1. Land-cover/use categories.**

<table>
<thead>
<tr>
<th>Land-cover/use</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>1. Mixed conifer forest</td>
</tr>
<tr>
<td></td>
<td>2. <em>Pinus jeffreyi</em> forest</td>
</tr>
<tr>
<td>Riparian vegetation</td>
<td>3. Riparian vegetation</td>
</tr>
<tr>
<td>Scrubs</td>
<td>4. <em>Juniperus</em> scrub</td>
</tr>
<tr>
<td></td>
<td>5. Coastal sage scrub</td>
</tr>
<tr>
<td></td>
<td>6. Chaparral</td>
</tr>
<tr>
<td>Grasses</td>
<td>7. Mountain meadows</td>
</tr>
<tr>
<td></td>
<td>8. Grasslands</td>
</tr>
<tr>
<td>Agriculture</td>
<td>9. Irrigated agriculture</td>
</tr>
<tr>
<td></td>
<td>10. Rainfed agriculture</td>
</tr>
<tr>
<td>Water bodies</td>
<td>11. Reservoirs</td>
</tr>
<tr>
<td>Urban development</td>
<td>12. Urban development</td>
</tr>
</tbody>
</table>
Calculating transition matrices

In order to describe the land cover / land use dynamics, we constructed Markovian transition matrices, considering landscapes as land cover / land use mosaics that can change dynamically, from and towards different land cover / land use categories. The probability that an area with land cover / land use belonging to category $i$ may experience a transition into another category $j$ is calculated as the ratio of the area that did change from $i$ to $j$ between 1970 and 1994, divided by the original amount of land cover category $i$ at the beginning of the study period:

$$P_{ij} = \frac{S_{ij}(1994)}{S_i(1970)},$$

where $\sum_i P_{ij} = 1$.  (1)

Transitions were evaluated in terms of both geometric and thematic consistency. Small differences in polygon area (< 0.02% for the whole basin) originating from tracing errors in polygon boundaries were not taken into account.

Results

The maps in Fig. 1 show land cover / land use in 1970-1972 and 1994, and the changes undergone in this period in the TRW. As expected in a basin with the marked elevation changes and coastal-inland climate gradients as our study area, there was a gradient of natural land cover types from the highest peaks to the lowlands (Fig. 1). On the US side, the highest areas within the basin are occupied by mixed conifer and Pinus jeffreyi (Jeffrey pine) forests. The highlands on the Mexican side are mostly covered by Juniperus scrub, and on both sides the high elevation valleys and plains harbour mountain meadows. Following the elevation gradient downwards, the basin’s slopes are mostly covered by chaparral, a particular type of sclerophyllous scrub, and further down, where the coastal fogs of the Pacific Ocean hit the land, chaparral becomes replaced by coastal sage scrub, which is richer in succulents and herbaceous growth forms. Finally, riparian land cover is found along intermittent arroyos or creeks at different altitudes, driven by moisture and water availability.

The first apparent feature observed in our data is that the complexity of the network of observed transitions is much greater in Mexico, with more transition pathways between different land cover / land uses than on the US side of the basin. Overall, natural land cover lost 253 km$^2$ in the basin, of which 202 km$^2$ (80%) were lost in Mexico (Tables 4 and 5). However, 55 km$^2$ of natural land cover were also recovered from abandoned grasslands and agricultural fields, returning chiefly to secondary chaparral, coastal sage scrub and mountain meadows. Most of this recovery (90%), however, was observed in Mexico, while in the US, natural land cover loss was almost irreversible. Globally, the rate at which natural land cover classes were lost in Mexico (0.4%) doubled that of the US (Table 2). Correspondingly, the rate of growth of anthropogenic land cover classes in Mexico was also higher than in the US (1.7% vs 1.2%).

In 1972, urbanization covered 2.4% of the basin; by 1994 it had extended to over 6.9%. Urban areas increased more than 200 km$^2$ in the whole basin, 74.7% of which developed in Mexico, in 85 patches. In the US, urban development only contributed 87 km$^2$, but was split into 110 patches (Tables 2 and 3). The perimeter shape ratio of urban patches was also different in each country: 13.8 and 17.0 in 1970 and 1994, respectively, in the US; and 8.3 and 10.7 in Mexico. In the US, urban areas expanded at an annual rate of 3.7%, mostly over

| Table 2. Land-cover/use (km$^2$) and annual rate of change (%) in the Tijuana River watershed. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | 1970 US 1994   | Rate (%)        | 1972 US         | Rate (%)        | 1994 US         | Rate (%)        |
| Mixed conifer   | 23.01 22.16    | -0.2            | -               | -               | -               | -               |
| Pinus jeffreyi  | 39.39 39.22    | 0.0             | -               | -               | -               | -               |
| Juniperus scrub | -               | -               | 260.67 228.52   | -0.6            | -               | -               |
| Chaparral       | 879.91 846.06  | -0.2            | 1 504.54 1 468.43 | -0.1            | -               | -               |
| Coastal sage scrub | 78.62 70.80 | -0.4            | 1 028.76 950.63 | -0.4            | -               | -               |
| Riparian vegetation | 35.35 31.03 | -0.5            | 61.63 79.65     | 1.2             | -               | -               |
| Mountain meadows | 16.92 17.37 | 0.1             | 54.04 31.14     | -2.5            | -               | -               |
| Grassland       | 45.81 58.85    | 1.0             | 139.28 132.59   | -0.2            | -               | -               |
| Irrigation agriculture | 52.00 27.55 | -2.6            | 39.31 34.22     | -0.6            | -               | -               |
| Rainfed agriculture | 0.00 0.00   | -               | 77.45 87.26     | 0.5             | -               | -               |
| Urban           | 35.62 87.04    | 3.7             | 69.62 221.02    | 5.3             | -               | -               |
| Reservoirs      | 3.94 10.20     | 4.0             | 4.84 7.39       | 1.9             | -               | -               |
| Total           | 1 210.56 1 210.29 | 4.0           | 3 240.14 3 240.85 | 4.0             | -               | -               |
| Total natural   | 1 073.20 1 026.64 | -0.2          | 1 405.10 1 289.94 | -0.4            | -               | -               |
| Total anthropogenic | 137.37 183.64 | 1.2             | 330.50 482.48   | 1.7             | -               | -               |
chaparral, irrigated agriculture and grasslands (Tables 2 and 4). Urban expansion in Mexico was much faster (5.3%) and expanded chiefly over coastal sage scrub, chaparral and induced grasslands, but also impacted heavily on other natural land cover types (Tables 2 and 5). As a sink land use category, urban development did not undergo further conversions; for all practical purposes it is an irreversible state.

Other anthropogenic land uses, such as irrigation and rain-fed agriculture and grasslands, that covered almost 7.9% of the basin, reduced their area slightly to 7.6% by 1994. Irrigation agriculture decreased in area in both countries, mainly in the US, but not so their number of patches, which increased in the US and were maintained in Mexico (Tables 2 and 3). Grasslands increased in area, but the number of patches decreased in the US. In contrast, in Mexico, grassland area decreased and patch number increased (Tables 2 and 3).

Patches increased in almost all land cover / land use types on both sides of the border, with the exception of induced grasslands in the US. In Mexico, fragmentation rates on natural ecosystems were much faster, and were especially high in the Juniperus scrub and the coastal sage scrub, while in the US the most severely fragmented natural land cover type was the chaparral (Table 3).

Table 3. Number of patches within different land-cover/use categories at the Tijuana River watershed.

<table>
<thead>
<tr>
<th></th>
<th>US 1970</th>
<th>1994</th>
<th>Rate (%)</th>
<th>Mexico 1972</th>
<th>1994</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed conifer forest</td>
<td>20</td>
<td>20</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pinus jeffreyi forest</td>
<td>3</td>
<td>3</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Juniperus scrub</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>46</td>
<td>82</td>
<td>2.63</td>
</tr>
<tr>
<td>Coastal sage scrub</td>
<td>8</td>
<td>10</td>
<td>0.93</td>
<td>28</td>
<td>46</td>
<td>2.26</td>
</tr>
<tr>
<td>Mountain meadows</td>
<td>33</td>
<td>33</td>
<td>0.00</td>
<td>68</td>
<td>84</td>
<td>0.96</td>
</tr>
<tr>
<td>Grassland</td>
<td>79</td>
<td>69</td>
<td>-0.56</td>
<td>240</td>
<td>443</td>
<td>2.79</td>
</tr>
<tr>
<td>Irrigation agriculture</td>
<td>71</td>
<td>73</td>
<td>0.12</td>
<td>53</td>
<td>53</td>
<td>0.00</td>
</tr>
<tr>
<td>Rainfed agriculture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>79</td>
<td>122</td>
<td>1.98</td>
</tr>
<tr>
<td>Urban</td>
<td>77</td>
<td>110</td>
<td>1.49</td>
<td>50</td>
<td>85</td>
<td>2.41</td>
</tr>
<tr>
<td>Reservoir</td>
<td>15</td>
<td>15</td>
<td>0.00</td>
<td>1</td>
<td>2</td>
<td>3.15</td>
</tr>
</tbody>
</table>

Table 4. Land-cover/use transitions for the US part of the Tijuana River basin between 1970-1994 in km². The values in parentheses indicate the transition probabilities, and the values in bold indicate the diagonal of the transition matrix.

<table>
<thead>
<tr>
<th>US 1970-1994</th>
<th>Mixed conifer forest</th>
<th>Pinus jeffreyi forest</th>
<th>Chaparral</th>
<th>Coastal sage scrub</th>
<th>Riparian vegetation</th>
<th>Mountain meadows</th>
<th>Grassland</th>
<th>Irrigation agriculture</th>
<th>Urban development</th>
<th>Reservoir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed conifer forest</td>
<td>21.70 (0.918)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pinus jeffreyi forest</td>
<td>-</td>
<td>39.22 (1.000)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chaparral</td>
<td>1.93 (0.082)</td>
<td>-</td>
<td>838.66 (0.958)</td>
<td>-</td>
<td>1.47 (0.041)</td>
<td>-</td>
<td>1.04 (0.023)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Coastal sage scrub</td>
<td>-</td>
<td>-</td>
<td>70.07 (0.901)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Riparian vegetation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>27.84 (0.781)</td>
<td>-</td>
<td>-</td>
<td>3.51 (0.069)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mountain meadows</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>16.76 (1.000)</td>
<td>-</td>
<td>1.08 (0.021)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Grassland</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.54 (0.006)</td>
<td>5.78 (0.074)</td>
<td>-</td>
<td>-</td>
<td>38.91 (0.851)</td>
<td>9.06 (0.178)</td>
<td>-</td>
</tr>
<tr>
<td>Irrigation agriculture</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.55 (0.003)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>23.52 (0.462)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Urban development</td>
<td>-</td>
<td>-</td>
<td>27.23 (0.031)</td>
<td>1.88 (0.024)</td>
<td>1.20 (0.034)</td>
<td>-</td>
<td>5.80 (0.127)</td>
<td>13.68 (0.269)</td>
<td>35.84 (1.000)</td>
<td>-</td>
</tr>
<tr>
<td>Reservoir</td>
<td>-</td>
<td>-</td>
<td>1.16 (0.001)</td>
<td>-</td>
<td>5.13 (0.144)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.92 (1.000)</td>
</tr>
</tbody>
</table>
Table 5. Land-cover/use transitions for the Mexican part of the Tijuana River basin between 1972-1994 in km². The values in parentheses indicate the transition probabilities, and the values in bold characters indicate the diagonal of the transition matrix.

<table>
<thead>
<tr>
<th>Mexico 1972-1994</th>
<th>Juniperus scrub</th>
<th>Chaparral</th>
<th>Coastal sage scrub</th>
<th>Riparian vegetation</th>
<th>Mountain meadows</th>
<th>Grassland</th>
<th>Irrigation agriculture</th>
<th>Rainfed agriculture</th>
<th>Urban development</th>
<th>Reservoir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juniperus scrub</td>
<td>200.25 (0.769)</td>
<td>21.98 (0.015)</td>
<td>-</td>
<td>-</td>
<td>5.94 (0.104)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chaparral</td>
<td>55.28 (0.212)</td>
<td>1391.32 (0.926)</td>
<td>2.70 (0.003)</td>
<td>6.76 (0.110)</td>
<td>5.39 (0.095)</td>
<td>4.98 (0.036)</td>
<td>-</td>
<td>1.20 (0.016)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Coastal sage scrub</td>
<td>-</td>
<td>16.99 (0.011)</td>
<td>891.58 (0.867)</td>
<td>7.81 (0.127)</td>
<td>-</td>
<td>24.68 (0.177)</td>
<td>1.64 (0.042)</td>
<td>7.93 (0.103)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Riparian vegetation</td>
<td>1.43 (0.005)</td>
<td>13.87 (0.009)</td>
<td>13.09 (0.013)</td>
<td>40.23 (0.655)</td>
<td>2.70 (0.047)</td>
<td>2.37 (0.017)</td>
<td>4.64 (0.118)</td>
<td>2.11 (0.027)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mountain meadows</td>
<td>2.15 (0.008)</td>
<td>2.72 (0.002)</td>
<td>-</td>
<td>-</td>
<td>25.81 (0.453)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Grassland</td>
<td>1.40 (0.005)</td>
<td>27.50 (0.018)</td>
<td>26.73 (0.026)</td>
<td>1.51 (0.025)</td>
<td>14.61 (0.256)</td>
<td>46.33 (0.333)</td>
<td>1.49 (0.038)</td>
<td>13.67 (0.178)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Irrigation agriculture</td>
<td>-</td>
<td>1.00 (0.001)</td>
<td>1.48 (0.001)</td>
<td>-</td>
<td>2.53 (0.044)</td>
<td>3.97 (0.028)</td>
<td>17.14 (0.436)</td>
<td>7.01 (0.091)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rainfed agriculture</td>
<td>-</td>
<td>6.69 (0.004)</td>
<td>11.72 (0.011)</td>
<td>3.11 (0.051)</td>
<td>-</td>
<td>18.82 (0.135)</td>
<td>11.08 (0.282)</td>
<td>35.98 (0.468)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Urban development</td>
<td>-</td>
<td>21.04 (0.014)</td>
<td>79.47 (0.077)</td>
<td>2.03 (0.033)</td>
<td>-</td>
<td>38.09 (0.274)</td>
<td>3.33 (0.085)</td>
<td>9.00 (1.17)</td>
<td>69.46 (1.000)</td>
<td>-</td>
</tr>
<tr>
<td>Reservoir</td>
<td>-</td>
<td>-</td>
<td>1.50 (0.001)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4.84 (1.000)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Discussion

As would be expected in an area where secondary and tertiary economic activities dominate, urbanization accounted for the larger transformations. On both sides of the border in the TRW, grasslands and agriculture were the forestates of urban development. Within the basin, urbanization showed two different patterns. One was the enlargement of existing patches, mainly on the Mexican side, eastwards along the international border, southwards along the Pacific coast and to the southeast along the Tijuana River. This growth took over grasslands, coastal sage scrub and riparian zones, interrupting the continuity of these ecosystems between Mexico and the US. The second pattern was formed by the development of scattered urban patches, growing over riparian habitats and chaparral in Mexico and widely spread in the US over grasslands and chaparral (Fig. 1). The higher perimeter ratio of the urban area in US reveals the higher fragmentation of urban patches on this side.

In the US the more dispersed urban pattern was driven by a combination of population growth, socio-economic encouragement of suburban growth, policies empowering local governments combined with lower taxes in rural areas and infrastructure construction; mainly highways, water and drainage, and other services (Ojeda & Espejel in press). In Mexico, a more compact and continuous urban pattern was driven mainly by population growth, especially of migrants in search of work, job creation policies (such as Border Industrialization Program, Zenteno & Cruz 1992), poor infrastructure investment that pushes newcomers to be near the limits of urbanization and lack of law enforcement preventing illegal land use change (Ojeda & Espejel in press; Velázquez et al. 2005). Indeed, almost 50% of the city’s area has an irregular settlement origin (Alegría & Ordoñez 2005).

The dynamics of the transformation process was much simpler in the US than in Mexico (Tables 4 and 5). The observed differences possibly reflect a series of driving forces, such as diverging urbanization growth patterns, different grazing practices in each country, the active role played by itinerant rain-fed agriculture and induced grasslands in Mexico (which allows the recovery of natural vegetation), and some conservation policies applied in the US that contribute to reduce the number of transformation pathways undergone by natural areas.

On both sides of the border, scrublands were the main source of land cover change, in part because they cover most of the watershed area and especially because they dominate in the flat lowlands where development has priority. During our study period, Juniperus scrub in Mexico changed mainly towards chaparral – its natural neighbour that takes over when Juniperus cover decreases as a result of wildfires and/or cutting for fuel and for the construction of ranch fences by the local populations (Minnich & Franco-Vizcaíno 1998). Chapar-
eral and coastal sage scrub, the dominant categories in the basin’s scrublands, had a more dynamic and diverse contribution to land cover transitions; transforming to every other land use type. Quantitatively, however, their reduction was chiefly driven by urban development, which occurred largely at the expense of chaparral in the US and of coastal sage scrub in Mexico. Quantitative and qualitative changes in chaparral composition and structure are caused by *rancheros*, who deliberately burn the scrub to improve browsing and livestock access, and by agricultural burns that increase without control (Minnich & Franco-Vizcaíno 1998). During our study period, some chaparral and coastal sage scrubs in Mexico were recovered from abandoned agriculture plots and induced grasslands, a process observed only in very small areas in the US (Table 5).

Coastal sage scrub is a unique type of land cover as it contains a great number of endemic species (Oberbauer 1999; Riemann & Ezcura 2005). Besides its diverse conversions to all kinds of land use, it has been used for cattle grazing since colonial times, with browsing preferences resulting in selective removal of some shrub species, and with the introduction of exotic species to make it more palatable for livestock (Minnich & Franco-Vizcaíno 1998). Burning practices are also common in this land cover type, and although it is resilient under periodic fire (O’Leary 1990), recurrent intervals of less than five to ten years will degrade it and lead to the dominance of non-native grasses, often promoted by open-range, transhumance cattle grazing (Malanson 1984; Minnich & Franco-Vizcaíno 1998).

In our data set, riparian land cover appears to have grown substantially between 1970 and 1994. This effect, however, is probably due to the 1992–1993 El Niño phenomenon, when the rainy season almost doubled the long-term precipitation mean (Anon. 2004) enhancing the growth of induced grasslands; after one or two cropping seasons they are abandoned, shifting spatially with time. The shifting of rain-fed agriculture occurs because of its reliance on modest and erratic precipitation, marginal soils for agricultural practices and lack of relatively flat terrains. This type of itinerant agriculture may allow the recovery of natural land cover as long as the agricultural plot is surrounded by natural patches that allow re-colonization.

According to Velázquez et al. (2005), in Mexico there is a ‘passive’ recovery of natural land cover due in part to the abandonment of small patches of land by farmers who migrate to urban areas or to the US, or to small scale conservation actions; and to the socioeconomic conditions in which *ejidos* and communities (common property land) live. In our study area this process was also associated to the spatial shifting of rain-fed and induced grassland cultural practices.

Conclusions

Transition networks were different on each side of the border, and were closely linked to contrasting policies and land use practices during the selected time period which was based on the industrialization by the *maquiladora* economy (Zenteno & Cruz 1992). Because of this, the main change that occurred over the entire basin was caused by urban development, although with different patterns on each side of the border, driven by a different combination of social, demographic, and policy factors.

Shifting rain-fed agriculture in Mexico, or suburban
development in the US, are some prime examples of the influence of societal patterns on natural land cover change. In political terms, the lax enforcement of land use plans in Mexico, compared to the US, is quite evident.

As a whole, on the US side of the basin, LUCC followed a simpler path, with major changes concentrated on chaparral and irrigated agriculture, being rapidly transformed into urban developments with induced grasslands as an intermediate stage. In the Mexican part of the basin the process was more complex; mostly because of the itinerant practices of rain-fed agriculture and grassland management, on the one hand, and of unchecked, badly planned, and very rapid urban development on the other.

In Mexico, rain-fed agriculture, which is very dynamic in time and space, played a key role and explained the much more complex LUCC patterns. Grasslands also added complexity and risk into the system dynamics; in Mexico their growth and productivity is governed by burning practices, while in the US burning is not a management tool.

The dynamic complexity of the land use mosaic imposed by Mexican itinerant land use is perceptible in other types of natural land cover such as, for example, the exploitation and subsequent recovery of Juniperus scrub, or the use of mountain meadows and riparian land cover for cattle grazing during rainy years. Recovery of natural vegetation occurs mostly on the Mexican side of the border driven by the shifting practice of rain-fed agriculture and grasslands. In the US natural protected areas imposed limits to LUCC in some parts of the basin.

Further research may consider the analysis of ongoing LUCC patterns, including the role that shifting rain-fed agriculture and induced grasslands may play in the recovery of chaparral and coastal sage scrub in the Mexican side of the basin. In addition, another potential research path could be the development of different scenarios for mid and long-term study for both sides of the basin and the basin as a whole.

In conclusion, our research suggests that, despite the need for an integrated planning and management of binational basins and shared water resources, in practice, these goals are hampered by the role played by different factors triggering land use change within each society. In any case, the challenge remains to build shared approaches and tools for planning and public policy formulation.

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