SONORAN DESERT RAPID ECOREGIONAL ASSESSMENT (REA)
Workshop 5 Summary

Phoenix, Arizona
September 19–21, 2011

Monday, September 19, 2011

Introductions

Elroy Masters provided welcomes and led group introductions.

Karl Ford presented a brief overview of the REA process. He explained the REA rolling review and the use of Data Basin as a data storage, display, and review site. He also told participants that we would discuss the outline for the final report at the end of the meeting: BLM is seeking input to ensure that the report will be useful to managers and BLM Field Office staff.

Jim Strittholt Presentation

Jim Strittholt of Conservation Biology Institute (CBI, Dynamac subcontractor) presented the results of several months of GIS analysis. He began the presentation by saying that he wanted to steer the discussion during the workshop toward meaningful issues rather than merely presenting a data parade (which would be easy to do with the huge quantity of material that has been produced). *Jim* went on to explain the review process on Data Basin in more detail, and *Karl* offered to add workshop participants to the group on Data Basin, if they were not already members, so that they might review the results. They also showed a slide of a portion of an excel file posted under the Supporting Documents tab in Data Basin that lists each management question and its completion status.

Jim listed the main components of the REA: conservation elements, change agents, and management questions. He also described other important REA components that are not addressed directly by management questions, such as conservation element status, predicted future conditions, an index of ecological integrity, and the identification of opportunities and constraints on the landscape. He showed examples of other tools for organizing information: conceptual models created for each conservation element, process models that explain the steps in developing map products, and logic models used to organize the thinking of the more complex multi-tiered models.

Jim showed an example of an attribute and indicator table that was developed for each conservation element. Although many indicators may be collected for individual conservation elements and placed on a gradient from poor to very good, only a small subset of these indicators will have appropriate spatial data to use in the REAs at the ecoregional scale. It is also important to select attributes and indicators that are sensitive to change agents and that are routinely updated (such as impervious surface, vegetation cover).

Current and Future Development Management Questions

MQ G1 Where are the current locations of these development types?

Jim recalled the Environmental Monitoring Decision Support Tool (EMDS) that was proposed for use at Workshop 3. Although BLM decided against the use of EMDS, CBI decided to rebuild EMDS in ModelBuilder and Python because its use of logic models and fuzzy logic make the complex rollup of components of the ecological integrity model easier for participants and reviewers to understand. This analog of EMDS will be easier to run, though it will lack some useful elements of EMDS.

Jim showed the logic model for the first development questions, MQ G1. Source inputs, intermediate results, and final results are color coded in the logic model and these colors are repeated in the results to help the viewer follow the process. He explained the use of fuzzy logic. We control the logic in various ways by:

- controlling the break points or thresholds. Regardless of the source data or units used, everything is put into a true/false question and put on a -1 to +1 gradient. Fuzzy logic allows consideration of shades of gray. Jim illustrates a linear function and a step function. He uses wolf sensitivity to increasing road density as an example for a quantitative indicator that can be used in a model such as this.
- controlling the location in the logic tree. Elements that you want to have greater influence are put higher in the logic tree.
- the use of logic operators *sum, or* (pick the maximum), or *union* (average)
- and the use of weighting. One can weight the components equally, change the weighting, put in new data sources or new future scenarios, and rerun the model. The weights for the various components of the development model were urban development, 40; agriculture, 20; energy development 30; and recreation, 10. Jim pointed out that all of the components started out with equal weights in the first run, and weights were added and tested in subsequent runs. Weighting can be modified and different weights tested at any point. Although weighting is subjective, it helps to capture the elements of changes agents working synergistically.

Karl Ford: During a development webinar several weeks ago, the weightings were altered after group discussion of the weighting of intensive agriculture and livestock grazing. Some think that grazing should have lower weighting than agriculture. *Jim*: We are trying to discriminate effects in the best possible way. The map is only as good as the data we put in. If I had herd density, it would make this model more useful. We were not given information on grazing.

The logic models show the thinking and are easy to understand, whereas the process models show the modeling applications used so that they can be replicated by other GIS users. *Jim* shows the process model for the high development piece, the intermediate results for the high urban, agriculture, energy and mining, and recreation components, and the final composite map for current development. He used the intermediate results for agricultural development to demonstrate the use of operands. The grazing base layer had a central dark-colored area of HUCs; if we had used an OR instead of a UNION, the intermediate results HUC map would have retained the darker color in that area. Instead, when UNION is used, the lower weighting of the grazing data and the averaging (union) change the color for the same group of HUCs in the results to a lighter color.

High Recreation Development Layer. *Jim* relates the problems with obtaining recreation data, including the lack of data for offroad vehicles. Recreation was a problem, tracking types and intensity. The recreation data was mixed—dots, polygons, and lines; the roads data was not attributed to identify paved, unpaved, on road or off road travel. *Karl*: The offroad layers are pieced together; some states have good data and others don't. *Jim*: If we had better data we could weight differently roads that receive heavy use and roads that get less use.

The intermediate results are presented for both reporting units: 5^{th} level HUCs and 4 km grid. *Jim* expressed his opinion that the 4 km results showed more detail and better represented condition, especially in areas of some relief where more intact landscapes tend to be in the headwaters; in such cases HUCs tend to cancel out the distinctions by averaging condition across elevational changes in vegetation and habitat. The 4 km results clearly showed the linear pipelines and transmission corridors in the energy and mining results.

Development results are averaged and don't always cover the entire scale of -1 to +1. *Jim* shows a histogram of the distribution of data and asks the group what should be called good, very good, or high development. *Karl* asked if anyone wanted to change the weightings. *Christina Vojta*: Why would agricultural development be weighted less than energy and mining (agriculture is 20 and energy 30)? *Sabra Schwartz*: Animals can use agricultural fields, but they may not be able to use energy production areas. *Jeff Lovich*: You could weight them all equally if you consider that a disturbance is a disturbance. *Karl*: It is very subjective, but we do have to make a call. *Christina*: It depends on the level of intensity of the agriculture. *Jeff:* For golden eagles and wind energy, there are high impacts. For other species, such as bighorn sheep, even recreation impacts will be high.

Charles Drost: Any synthesis assumes that you get one result that represents everything. Charles is not comfortable with the concept of rolling it all up. *Karl*: You'll see that this will get rolled into ecological integrity. *Sabra*: This is a model to ask different questions. The whole point is that this is dynamic. You can ask different questions. *Jim:* If you knew thresholds, you could define a model specific to an individual species. It is reasonable without knowing thresholds to show us how we are doing. *Christina:* You could change the top box to be level of development. If it is species specific, can we hold off the weightings until we are showing maps of individual species? *Jim*: The best we can do is to show you how this works, leave you with the tools and let you come up with your own questions. The purpose here is to give the BLM managers the tools that will allow them to change and customize the models. We want to avoid delivering only a bunch of maps; the tools must be useful. *Sabra*: With new input, how do you envision us using it? How will people be able to go into it and modify it?

Karl: Renewable energy changed in just the last few months. Only BLM lands will be represented in the REA because there are no national databases. *Sabra*: We've been accumulating data. That's why I am asking, so we can put in our own additional data. There will be greater impacts from private lands. *Tim Hughes*: How dynamic will that be to put in new data? *Karl:* All data and models will be housed at BLM so that they can be used. We hope to refresh these on a 5 year basis. *Sabra*: The maps but not the tools. *Karl*: Yes, the tools will be there. *Jim*: We have the tools that we have already built and would like to host the tools live on Data Basin.

Christina: Back to the weighting. Up to this point, nothing else is value-laden but the weightings. The value of a tool comes from allowing users to do the weighting. It depends on what species we are talking about. *Jim*: We can weight all factors equally (or not weight them) or we can weight them. These questions really fall under the integrity piece. We will see more of that tomorrow. This is just the first piece; it is highly versatile, which is both good and bad.

Charles: An alternative is to look at it not as an absolute impact but what BLM has some control over. What do they have reasonable management purview over? It makes more sense to highlight what is important and concentrate on areas where we have some influence. *Jim*: Then you would lose the context of lands not managed by the BLM. You would lose the value of the areas surrounding BLM lands. *Elroy:* Since it is a landscape view, this is development only. Later we'll see tradeoffs. Here we are asking, What is the footprint on the landscape that is going to feed into the next level? *Karl*, referring to the final map of HUCs for development: Where are areas of largely intact vegetation and habitat? Good areas, although maybe not intact, we might try to protect. If it is degraded as in highly developed areas, maybe we funnel new development into areas that are already degraded. Intermediate areas might be restorable. It is a zoning concept.

Todd Esque recalls when it was decided not to use EMDS. I'm glad that you went with this to recreate EMDS. If we proceed carefully, this is going to be a good way to go and I'm glad you invested in this. I've seen the ability to resolve big questions, even though there may be pitfalls. *Jim:* If there's a piece that doesn't work, we can remove it and do without.

MQG2 Where are areas of potential future development?

For the 2025 projection, Jim showed the High Development logic model with several items added to represent potential future development: renewable energy data and David Theobald's urban growth projections. One could also add utility and pipeline data. The logic diagram shows how new source data can be added to come up with new/different projections of the intermediate results and the final results. In this diagram, most boxes remain the same as for the Current Development logic diagram; the yellow boxes are the only two factors being changed. Two slides show the intermediate results for urban development with urban growth data and renewables with solar expansion.

Jim shows several slides of current and future development side by side, HUC and 4 km results. The changes are evident particularly in the corridor between Phoenix and Tucson.

Invasive Species Management Questions

MQ F1 Where are tamarisk, buffelgrass, red brome, Sahara mustard, quagga and zebra mussel, and Asiatic clam present?

Jim shows a slide of fire-human activities-invasive plants interactions. *Jim*: This is a rapid assessment. Our objective is to show the connections between the CAs and CEs that we've been asked to look at separately. We would like to deal with the synergies, but we can't delve into it too deeply. We know about the synergies and the fact that each of these elements is a research area in its own right.

Tamarisk

Jim: We had various data types for tamarisk: point, poly-line, and raster (potential distribution model, Jarnevich et al.) at 1 km resolution. We needed a way to put it all together. *Jim* gives an example of massaging the data. They played with the cutoffs in the Jarnevich model: they kept areas with probability of 60% or higher and then overlaid the linear hydrological datasets.

Jim shows several zoomed in views of tamarisk distribution and shows the HUC and 4 km results. *Jim Weigand (on the telephone)*: The maps look good in California. Some linear additions might help, like the All-American Canal.

Buffelgrass

Buffelgrass and red brome both had scant data. Buffelgrass was represented by SWEMP07 and Southern Arizona Buffelgrass Coordination Center (SABCC) occurrence data and also the invasive grasses class from LANDFIRE.

Jim shows a detail view of buffelgrass distribution near Tucson and another with the impervious surface overlaid to show the relationship of buffelgrass to road networks. Finally the distribution is shown in both HUC and 4 km reporting units.

Jim Weigand: It is difficult to represent the California portion. You might talk to buffelgrass experts. *Todd Esque*: Tom Van Devender and Matt Brooks have numerous sightings, but they are not published. *Karen Simms*: The Sonoran Desert Museum should have maps of buffelgrass distribution. *Jim Weigand*: You could look at areas where roadside ignitions are common. *Sabra*: Cal IPSI? *Jim W.*: I don't think that they've gotten that far. They do have a web portal for forecasting, but are focusing on Mediterranean weeds. *Jim S:* This information is part of the integrity function. If we know what invasives are likely to do, it will help forecast integrity.

Red Brome

The red brome data from the SW Exotic Mapping Program 2007 (SWEMP07) is quite sparse. To supplement the SWEMP data, *Brendan Ward* (CBI) used LANDFIRE predictions of red brome areas at recently burned sites. *Brendan* explained how LANDFIRE predicts areas of red brome in areas departed from the former fire regime. Their models indicate the potential for the landscape to support red brome, not actual current distribution. Post-burn areas with the appropriate site potential are assigned to red brome.

Todd Esque: Is the data accurate enough? The polygon for the Harcuvars was red brome when it burned. *Karl:* We need to assign confidence levels to derived products. *Jim W:* Thinks red brome is much more extensive than what is shown. *Tim Hughes:* Red brome is virtually everywhere. The threshold is whether it is dominant or will carry fire. This varies year to year and is very dynamic. What is the best way to capture this? *Christina:* There are researchers from Northern Arizona University looking at red brome on military lands. They may have data that they're willing to share. *Tim:* Most of the polygons shown south of I-80 are on military lands.

Jim and *Brendan* go to Data Basin to look at the current distribution of red brome. *Karen Simms*: Why haven't you asked for local monitoring data? *Elroy* answers that the contractors were not to bother the field offices. Also, that the local monitoring data are all collected in different ways. This brings up questions of how to put it all together to use in the "roll-ups" when the data are not collected consistently. *Karl:* It's the same with the recreation data. The scale of the data sets from the field offices don't match. We know that there is better local data. *Elroy:* For stepping down from the REAs, BLM staff can insert local data to make individual decisions. *Karen:* That may mean that certain areas will not be considered because the data is missing or wasn't used. *Elroy:* Then we can argue to improve our red brome data and get funding to do it. *Brendan:* We requested ILAP data, but were refused due to data-sharing agreement issues and timelines. So, given the relatively vague question of "where is red brome" and the lack of data, what thresholds on what we call red brome sites will best help you? *Jim:* If we don't like the data, we have two options. We can either provide caveats or we can drop it. We need guidance from BLM on where to draw the line so that people understand the quality of the data and the results. *Karl:* It appears that the data don't allow much confidence. Land cover is based upon dominance; could we put 200m buffers around occurrence?

Todd: Red brome is important because it is changing the land cover. Sometimes it isn't ranked at all. We don't want to be irresponsible, but we don't want to ignore it. It's a tough question because there isn't much data to model. So how can we know what the maps show? He picks out a polygon on the map that he knows well. Red brome is not what caused the fire here; it burned in 2005 and afterwards was just dirt due to drought. There is a risk of it coming back as buffelgrass and Sahara mustard. The cover of red brome is unknown, but there's no reason to believe that it is dominated by brome. The area south of the interstate didn't grow back to red brome.

Jim: If we roll it up as an invasive risk, a collective piece of invasive annuals, would that be a better way to portray than specific invasive species? It could then be teased apart later. *Todd* agrees that this might be a better way, a compromise that shows risk of invasives rather than specific invasive species. *Others in the group agree.*

Jim S. to Jim W.: Have you looked at Sahara mustard results? The point data for the Sahara mustard were buffered by 200m. *Jim W.* had not yet looked at Sahara mustard and said he will get back to CBI on it; so we skipped Sahara mustard and moved on.

Jim showed Todd and the rest the major invasive species rollup as a compromise for the What is actually there? question. All four invasive species were summarized in the HUC5 and 4 km results as the major invasive vegetation species current distribution.

MQ F2 Where are the areas of potential future encroachment from this invasive species?

Brendan Ward (CBI)*:* LANDFIRE succession class was used for prediction. It isn't a process-based model and it is not linked to disturbance. These efforts are to map the likely potential for new areas going to dominance by invasives, areas that are likely to be suitable for them. *Brendan* showed results maps of current invasive species distribution (the two species covered in this REA) and future encroachment. The future encroachment map does not show present plus additional invasion, but shows just the added increment. The current distribution and future distribution are exclusive of one another, but the last slide shows them combined. He asks if it appeared that we're going in the appropriate direction. *Jim:* The emphasis is on elements that drive plants in the future; precipitation, temperature, etc., including considering climate change. But human activities can override predicted potential. When we project into the future and the model shows that vegetation may change to a different type, it is done independently from human changes. Climate changes in temperature and moisture predict changes from C3 to C4 grasses, but we don't know how human activities will alter that. For example, areas that were grasslands in the past that currently are desert are due to human activities, not climate change. So the potential to change land cover due to climate change can be overridden by human activities whether or not the climate changes. We don't know how anthropogenic input will affect changes.

Elroy: Looking at some of the corridors, the future view is more like the current view. *Several others* agree that the current is like the future projection. *Jim*: If we put in the red polygons as current are we overestimating? Still underestimating, the group says. *Karl:* So a confidence statement would need to include the direction; whether it is an over or underestimate. *Karen:* If the polygons represent true dominance then they may be accurate, but if they represent only occurrence, they may be an underestimate.

MQ F3 Where are areas of suitable biophysical setting with restoration potential?

Jim: We haven't yet dealt with this question. We are still gathering the available data and input. So we'll move on to the next question.

Wildfire Management Questions

MQ E1 Where are the areas that have been changed by wildfire between 1999 and 2009?

Brendan Ward went through the process model and listed the data sources for the fire question (yearly fire perimeters from GEOMAC 2000–2010). They also extracted yearly fire severities (low, medium, high) from LANDFIRE disturbance class (1999–2008). *Jim*: We've got data from 1999–2010 from two different sources. Where the time period overlaps there are slight differences in the polygons where the two entities are mapped.

Doug Havlina: GEOMAC? *Brendan*: Yes, GEOMAC for fire perimeters. MTBS was used for severity, satellite-imagery based change analysis. The upshot is they didn't necessarily capture small fires, but have good representation of larger fires.

The results maps show 4 km and HUC results for areas burned 1999–2010 and a map of the fire perimeters by severity.

MQ E2 Where are the areas with potential to change from wildfire?

Brendan Ward: (*Brendan* worked with *Alex Syphard* [CBI] on the model.) We used a predictive model for fire future. We did it because there was no data available. We used MaxEnt with lightning density data, distance to roads, urban areas, water plus a few climate predictors (e.g., average annual and summer temperature and precipitation) and the database of fire occurrence points. We dropped other predictors because they were not useful. *Karl*: You used existing fire to train the model? Yes.

Brendan shows several slides of the process model and the MaxEnt input surfaces. We used the same surfaces for natural and human ignition and built four predictive models: High Probability of Human-Caused Fires, High Probability of Large Human-Caused Fires (> 100 acres), High Probability of Natural Fires, and High Probability of Large Natural Fires (> 100 acres). There were significant differences between human and natural caused fires. The likelihood of fire occurrence was turned into a binary result and 15% of the data was used as validation data. They are independent models meaning that one view isn't necessarily a subset of the other. They appear to be much more accurate with the subset of large fires than all fires. For the final results, we counted the number of models that agreed as a measure of confidence. If they all agreed, there is a higher likelihood of fire. If fewer models agree, there is lower confidence. From this effort, the models indicate approximately 25,000 human caused fires and 1600 naturally caused fires. *Observation:* It appears from the model that the Salton Sea has caught fire. This is a problem. *Jim/Brendan:* Not all the points are spatially accurate. The 4 km climate data may have eclipsed the interstate highway burns because they're too small.

Brendan shows results maps for each of the four models as well as combined results and model agreement. He states that this was trained on 30 years of historical data and does not necessarily indicate where fires will occur in the future. What isn't represented is the strong influence of invasives. *Brendan* shows the AUC tables and summary AUC values for each model. AUC is a measure of how well the model is predicting relative to the test data. *Jim*: The ones that drive the results are the top few: vegetation condition, annual precipitation, road distribution, and lightning. Evapotranspiration was located low within the table and was dropped.

Kevin Grove: It seems that winter precipitation is underestimated. *Brendan:* It's a limitation that these variables are averages, because it is the extreme years that hurt most. *Jim:* In climate modeling we've used MAPSS to obtain additional information on runoff, leaf area index (LAI). However, these get at averages as well, and are snapshots in time. We would like to use MCI models because they give monthly data which would track variability and allow us to see the extreme years.

Ted Milesnick: It appears that human caused fires should be more connected to roads. *Brendan:* These were picked up in the southeast. *Jim*: But if we get back to the question – which is more important, the occurrence of fire or of large fires? If we settle on the larger fires, it may be more accurate. *Jeff Lovich:* If you add up all the small fires, we may find that the small fires are more important. *Brendan:* We don't have good data for the area of small fires. Averages are driven by large fires; medians driven by small fires.

Karl: Is there a management question related to fire and climate change? *Jim:* CBI added climate change data and ran it in MaxEnt. It showed a pattern, but it didn't make sense. There were too many synergies in the pieces and too many feedback loops. We're not comfortable with the results, but we wanted to show it anyway. (They show the slide with climate change results.) We need a dynamic model to do this properly, MCI would be better. *Brendan:* One can compare the future prediction with the present and take a difference to denote potential change in high probability of fire occurrence. The two classes are *loss of high probability* and *gain of high probability.* The maps show mainly a "loss of high probability". This doesn't make sense unless the fuels are not growing. *Karen:* Aren't the climate change models also predicting a loss of winter precipitation? If we think winter precipitation is a major fire driver, this may

make sense. *Todd:* Yes, if the winter precipitation is less and the area gets drier, nothing grows and there's nothing to burn. Then we could see less fire occurrence. This is the scenario we've talked about in the Mojave; it may be that there is nothing left to burn. *Jim:* Winter precipitation in Data Basin for the 2045 – 2060 time period shows much less winter precipitation. *Karl:* I agree with Todd, don't throw this out, it may be correct if due to lower winter precipitation. *Jim:* We didn't know what the major driver was. If winter precipitation is the main driver, we may not need to add the summer season. *Jeff Lovich:* What about the effects of the monsoon farther south? The monsoons decrease the large fires after early July; how might they affect the eastern edge of the SD? Buffelgrass responds to summer precipitation.

MQE3 Where are fire adapted communities?

Most fire-adapted vegetation communities occur on the edges or outside the Sonoran Desert ecoregion. The data used for these maps came from the Reference Condition Fire Regime in LANDFIRE. State and transition models, VDDT predicted fire return intervals by pixel. The data integrates historic fire frequency and intensity. 100-200 year return intervals are not considered fire-adapted communities; 50 years or less fire return intervals are considered fire-adapted communities. Also, if it wasn't mapped as chaparral in LANDFIRE reference condition, it wouldn't be mapped as fire-adapted. *Elroy:* Instead of using reference condition, should we be using existing vegetation? *Jim to Brendan:* Could we superimpose a present vegetation layer on top of reference condition to refine the results for fire regime? *Brendan* gives a suggestion on how this might be done.

End of Day 1. Jim previews Day 2.

Tuesday, September 20, 2011

Karl: Everyone please think about the content and design of the final report. Encyclopedic is not an option. We don't want it to be 1000 pages because we want it to be read by landscape managers and the public. So the bulk of the content will go into appendices. We need to think about what stories we want to tell that will go into the body of the report. Also, keep in mind that the report is not a "decision document." Instead, it is an informational tool.

Charles Drost: What does BLM want to get out of this meeting? *Karl:* This is a preliminary results workshop. It's been a long road to get here, this is Workshop #5. 1000's of maps are being created, more than anyone can assimilate. However, not everything is done yet, so we want input on individual data sets and models, as well as input on steering the final report; to get a vision of how the results should be presented. *Elroy:* In regards to representing the data, we need to know if it is sufficient. Field offices can use the data housed on the portal. We need to be able to explain and understand the quality of the data. *James Callegary:* The ecoregional perspective helps us to see the forest (for the trees) and get above the myriad details.

Index of Ecological Integrity

Jim: The REA began with a set of Management Questions (MQs) that repeat for each Conservation Element (CE). Organizing the data was painful, but that alone is worth doing. Some data will help answer the higher level questions and some will not. Each MQ is a research project in itself and although we've kept them all in mind, we cannot research them all. Therefore, we picked two things to advance the entire work. These are Ecological Integrity and Climate Change. Climate Change will add significant value to the entire process; it's part of each MQ or affects it. Today we'll focus on Ecological Integrity and tomorrow will be Climate Change.

What do we want from you? We're not experts on the Sonoran Desert, you are. No one knows it better than this group of people. So we need to know if our approach works or not. This will help us finish the job and produce a report that will be used.

Jim begins the presentation on Ecological Integrity with two definitions, one from the REA Scope of Work and the other from Karr and Chu (1995). He explains that integrity indices have been fully developed in the aquatic realm, but that they are still rare for terrestrial systems. Indices of biotic integrity developed for aquatic systems are built on survey data and relative abundances. He uses an analogy of ballroom dancers. There are three main threads: 1) the stage or ecological setting, 2) the biota or "dancers", and 3) the processes or "the dances." To understand ecological integrity, we must know who is there, how they're doing, who they're doing it with, the disturbances and responses. It is not enough to know if this or that species exists. We must know if it is viable. For high ecological integrity, all three pieces need to be working well together.

Jim: To what degree can we establish thresholds that will allow comparisons between regions (especially if we use terms of poor, fair, and good)? As climate change occurs, can we use the same yardstick? He begins with the logic model from Memo 3 showing the main branches of the ecological integrity logic tree (Landscape Value and Ecological and Biological Integrity Value). He notes that we have spent the most energy on the landscape value arm of the logic model that represents species habitat. We can then interject biological information to tell us more. In this logic model, Landscape Value is the stage and Biological and Ecological Values are the dancers. Referring to the two arms of the Landscape Value portion of the logic model, Jim states that we're more confident about the data on terrestrial landscape intactness than aquatic intactness. *Jim* shows another, more complex logic model where the objective is to map terrestrial landscape intactness.

Jim: Yesterday, we spent time on how the models were developed, weighted and controlled for development. Today's models for Terrestrial Landscape Intactness include the development pieces; the weightings for the two development pieces are 65%, invasive species 10% and natural habitat fragmentation 25%. We start with models that are more complex and unpack them to remove redundancies. The habitat fragmentation metrics help us understand habitat quality. The metrics include not only the number of acres that are a certain habitat, but also the status of that habitat. In addition, how the habitat is configured within the larger landscape matters: big blocks vs. small pieces.

Ben Lomeli: Why is mining included under semi-permanent development? *Jim:* Because technically, the land can be restored. It can be argued that it's more likely to be restored than areas that are under pavement. So this is how the model is being run, but we can change it based upon the group's input. *Karl:* Assuming that within 40 to 50 years, the mines will be depleted and the companies will have to restore the land.

Ted: Why isn't fire included as a change agent? *Jim:* It's included in the future piece. We didn't want to complicate the model. Invasives are a good surrogate for fire, but as climate change occurs, the fire regime may change. *Karen:* Did you also consider native species that might increase more than normal in addition to invasives? *Jim:* No, except as vegetation patterns may change with climate change.

Elroy: The diagram is heavily weighted toward development. What about departure from a reference condition? *Jim* reviews how road density affects wildlife and how communities change when humans bring in other species. Human interactions with the biota have consequences. Therefore, development should be heavily considered in the model. *Karl:* Thoughts on shrub invasion; Nature Serve is using a variable called "S Class" vegetation from LANDFIRE. It may relate to site potential. *Elroy:* Land use plans require maintaining condition over time. What do we have today and where are we headed? *Karen:* Land use plans point to a desired future condition. There are always key attributes that must be maintained because they hold the system together. We need to determine what the structural pieces are (for example, soil structure). *Christina:* The climate change models show what communities it might go to climatically independent of human influence. Do we want to restore this plant community knowing it is already under stress? The different scenarios may point to assisting a community that is not anticipated now, but might be more likely in the future. This may give us better way to plan and invest resources.

Landscape Fragmentation

Jim moves to the natural habitat fragmentation arm of the logic model.

Jim: For fragmentation analysis we used FRAGSTATS. FRAGSTATS is not just an area game, but the spatial configuration of natural cover. The result can be rerun as changes occur in the future. FRAGSTATS runs metrics for the patch level, classes of patches, and the landscape level. Our effort used class level metrics that are appropriate to the ecoregion scale. We began with five classes. Those that gave redundant results (% natural and landscape contagion) were tossed out. We tried to limit the number of classes because it makes the results more easily understood.

The metrics used in the model were run on each class: Natural Vegetation, Semi-Natural Vegetation, and Other. Semi-Natural Vegetation includes the invasives footprint. The class *Other* masked out roads, agriculture, development, and water. We may need to run this model again because of yesterday's discussion about invasives possibly being under-represented. Jim shows a slide of the overall natural fragmentation classes and a collection of preliminary HUC results for the three fragmentation metrics: mean nearest neighbor distance, number of natural patches, and percent natural core area.

Defining the edge of a patch constrains a core area. The % natural core area can be manipulated by adjusting the distance from edge to core. We chose to buffer by 90 meters to discriminate edge from core. Core areas may be very different sizes and of varying utility depending on the shape of the initial patch. Disturbances are greater on the edges; therefore, the more edge there is, the more degradation, in particular by invasives.

Ammon Wilhelm: Can the different types of roads be weighted differently? More heavily traveled roads vs. dirt tracks? For habitat fragmentation it is more important to focus on larger roads, but if species are sensitive to OHV use, you might emphasize different things. *Jim:* For the general model we used the paved roads and not the dirt tracks. However, this can be changed for other species.

Karen: Thinking back to the ag model from yesterday, how was grazing handled apart from ag? In particular, grazing on "natural landscapes"? *Jim:* We're asking a different question today. Yesterday, we were asking "what is the basic human imprint?" Today we're asking "where are the places with the least impact?" He points out that roads are in the logic model twice. This is OK because they influence different pieces of the model because different questions are being asked. *Christina:* If a surface is not impervious, is it not a fragmentation of the landscape? *Russell Scofield:* In the Mojave, if you limited fragmentation to just paved roads, you would be missing a lot of rural development. *Jim:* This is a data issue. We don't have the attributed data to pull the paved apart from the non-paved. *Russell:* The county data would separate paved from non-paved. *Jim:* We were told to use the BLM data provided, which didn't discriminate between paved and non-paved. So, because the logic still works, we might be able to do this if the data issues were resolved. *James Callegary:* It is important to note these things as lessons learned and recommend resolutions as we go along. *Ben:* It is important to understand the relationships between the processes; e.g., what holds the system together. *Jim*: We will especially need help with Aquatics.

Jim showed the intermediate results for invasives, permanent and semi-permanent development, and FRAGSTATS. A union of the intermediate layers resulted in a final HUC results map of terrestrial intactness. The most intact areas were a darker green and the least intact areas light green.

The number of natural patches metric gives an indication of how much the landscape is broken up. The number of natural patches range from 9 to 5072. The mean nearest neighbor metric is a measure of the mean distance between natural patches within the same HUC. *Karl:* What about the Mexican border? *Jim:* The model currently stops at the border. If we ran it to go across, the border would act as a road or

wall. *Karl:* It seems that the fence may play a role in fragmentation that should be considered. *Jim:* We would need data that goes across the border; then we could re-run the models.

Jim: In looking at the various results of the intactness models, the dark colors indicate better intactness than do the lighter colors. It is critical to understand that the data behind these maps are numbers, but we can select lots of different ways to portray them: 1) natural breaks, 2) equal interval breaks, or 3) equal area/number of classes. We want to choose the number of classes that sufficiently represents and discriminates changes on the landscape. Note: We come back to this after the break.

Jim explained that they ran the fragmentation model using HUCs as the reporting unit. They would like to do it and summarize with the 4 km grid cells, but they have not completed that yet. It requires using a nearest neighbor/moving window analysis to smooth the surface as it moves across. The problem is that the new version of ARC does not support FRAGSTATS. The Dynamac team feels that the 4 km results give better information, because they represent topography and elevational changes better than the HUCs that tend to span elevational vegetation changes and average out the higher integrity areas in the headwaters. The 4 km version gives a more informative grain and the HUCs tend to muddy the signature.

Christina: Isn't a 4km grid cell homogenous? *Jim:* No, they're made up of 30m pixels. *Todd:* I think it is worth doing to refine the 4 km results. Managers will need it for issues like connectivity. *Christina:* I've never liked using the metric "# of patches" because all it takes is one pixel to create connectivity. *Jim:* That can be controlled by creating a rule set. *Christina:* Rather than using the term habitat, use "Fragmentation of Natural Cover" or "Natural Communities". That way people can't say "it doesn't work for my species." Also, we need to find a way to include protected areas, to figure out the distances between them. *Brendan:* Patch connectivity is highly pixellated because of sensor error. Should we smooth it first? *Jim:* I thought of that. If we combined the vegetation communities, the salt & pepper areas went away. *Brendan:* Why use three classes? Why not just look at natural and everything else? *Jim:* I kept three classes because we might want to apply the invasives issues later on.

<u>Deciding on Thresholds or Breaks in Integrity Classes</u>

Jim begins with the question: "How do we best display the thresholds for the various intactness values?" The EMDS standard for the thresholds includes seven classes. *Jim* showed a slide of an EMDS truth values table. It is divided into 7 classes, from no support through full support, with an undetermined 0 value. Four breaks were suggested in the SOW, analogous to classes like poor, fair, good, and very good.

We need to turn these seven classes into four. The way we define the break points is important because they will give us different maps. The breakpoints must make sense by adequately representing what is on the ground and provide information that is clear to the viewers of the maps. Jim then showed mapped examples of Terrestrial Intactness with different breaks (natural breaks, equal interval and EMDS breaks) and stated that his tendency in this example is to use the EMDS breaks and bundle "weak support to no support" (-1.0 to 0) together as Poor, "underdetermined to moderate support" (0 to 0.5) as Fair, "moderate support to strong support" (0.5 to 0.75) as Good, and "strong support to full support" (0.7 5 to 1) as Very Good. (His thinking was that if the scores were negative at all that then the area is not intact.) The best way to evaluate the utility of the breaks is to compare the maps with what is on the ground. We must calibrate the models. And if the model shows inaccurate maps, we need to determine if we need to change the breaks or if we need to change the logic.

Charles: We will need examples in the report to help communicate to the reader what we're trying to show. *Jim:* We could include snapshots of the different classes (e.g., poor, good, very good) to give the reader a visual understanding. We could also add actual photos to illustrate the different values; possibly something from Google-Earth. *Karen:* Images would be very helpful. AZGFD and AZDOT are working

on connectivity. When their work is done, it would be good to overlay their results. Will we be allowed to add data? *Jim:* Yes, you can add data now.

Russell: In thinking about how BLM will use the information, is there a way to use semi-permanent disturbance or semi-natural areas to identify areas for restoration? *Jim:* Yes, the models can help managers prioritize areas where connectivity might be reestablished. On the other hand, it may not be good to plan restoration in an area that is slated to change. It may have political utility as well as scientific to have a discussion about the wider area instead of only certain targeted areas (e.g., ecoregions rather than a National Park).

James: Will we be able to manipulate the data and logic models in the future? *Karl:* Yes, you can currently manipulate the data in Data Basin and you'll eventually be able to do so within the BLM portal with the exception of proprietary information (e.g., oil and gas). *Jim:* The Data Basin analytic tools are being built for use by non-GIS users. Our goal is to make it user-friendly. The difficulty is in producing a tool that will retain the integrity of the model and not allow the production of nonsense. With "cloud computing" we can handle bigger and bigger models and file sizes. Cloud computing is here to stay and will get faster. Both EMDS and ESRI use it.

Elroy: How will we relate the MQs to "good", "fair", "poor"? There'll be multiple inputs. *Jim:* What defines "good", "fair", "poor" depends upon what you're asking. So you'll need flexibility to get at the core elements. I'm showing it here in the roll-up, but it will be true for each element as well. *Elroy:* What are the landscape level elements needed to address quality values? What criteria? How do we tease out the landscape metrics that we can track over time to define "good", "fair" and "poor"? *Christina:* Our criteria are the top four boxes (invasive species, permanent development, semi-permanent development, and natural habitat fragmentation). Are you asking for different criteria? *Brendan:* Whatever breaks are used, they still give relative values, not absolutes. For example, the model will show "lots of roads" vs "fewer roads", not actual numbers of roads. *Jim:* We're struggling with how to best make people interpret the maps on the relative scale and not as absolute truths. *Karl:* The SOW/TO states that breaks need to be between low, high, and very high, or poor, fair and good. The BLM needs some consistency across the different maps. I like the consistency idea, but I just don't know how to do it. *Jim:* If we understand the thresholds, we can adjust the models.

Elroy: I understand how to layer it for individual species. *Jim* previews how he will use intactness layers with individual species to make statements about status.

Ammon: Instead of using values of good, fair and poor, it may be better to explain which areas are most intact and which are less based on the colors of the map. *Karl:* We can use the maps as a "zoning approach", e.g., protect the most intact areas, look at semi-degraded areas as restorable, and possibly funnel development towards those areas that are least intact. *Jim:* I wouldn't necessarily treat all degraded HUCs in the same way. Some may have different management possibilities.

Jim shows a slide of the logic model for future terrestrial landscape intactness and notes that the future intactness model will likely incorporate both fire and climate change. To make the logic models most useful, we must be able to refresh them when new data are available. The power of GIS models is not in their descriptions, but in their prescriptions. Visualizing the future may influence today's decisions. *Karl:* Add renewable energy to the model? *Jim:* Permanent or semi-permanent? *Karl:* Solar as permanent, wind possibly semi-permanent. *Jim:* Solar and wind are different, but will need to be added. I also suspect that irrigated agriculture will give way to urban development, but for now we aren't going to mess with it. We also don't want to predict future ground transportation. But these changes will influences changes in water use. *Christina:* Climate change will affect where development will go based upon water

availability. *Jim:* The climate change models indicate that potential changes may be different than expected. We might want to add water availability/stress as an indicator.

Aquatic Intactness Model

Jim started the discussion of the aquatic intactness model by saying that he was not satisfied with it. The data is not complete enough to create a robust model. The logic model has five intermediate components that are averaged to create the model of aquatic intactness. The components and their weights are: Invasive species (10), Water Use (10), Water Quality (30), Land Use (25), and Aquatic Fragmentation (25). There's pretty good data on aquatic fragmentation because there's been a lot of fisheries research. The data on dams are inadequate because only the biggest dams are included. Water diversion data is also inadequate and more is needed for water use and water quality. *James:* Most of these data don't exist except water use by county. *Jim:* The data on invasive species, e.g., mollusks, are suspect due to gaps. We think the points are only where researchers surveyed, not all the actual locations where they're found. *Sabra:* The University of Kansas should have information on invasives (crayfish and bullfrogs).

Elroy: Some rivers are managed for non-natives as sport fisheries. Also, where do artificial waterways fit into the model? Is there a data set? For 303(d) maybe only the headwaters of the Bill Williams River. *Sabra:* We have stocking site data for sport fish and we have data on catchment sites (same as guzzlers?). *Jim:* We'll try to track down these data.

Charles: What exactly is meant by intactness for aquatics? *Jim:* These are the places where natural water flow and quality is maintained. It is analogous to integrity. *James:* Is water use meaningful to intactness? *Jim:* The more human water use, the less intactness, especially as the climate gets drier. It's important to maintain water flow to maintain species. *Karen:* I see that water use is weighted low. Is that because of the data quality? Yes. *Karl:* BOR data sets of the Colorado River Basin show current and anticipated future flow. *James:* Arizona treats wastewater and puts back into the waterways. Therefore we have some permanent reaches where none used to exist, but these areas have water quality issues. That makes the issue complex. *Charles:* I have a similar thought on the logic tree for fragmentation. Sometimes the fragmentation is beneficial. *Karl*: Some of this depends on whether you are looking at the scale of the ecoregion or at the local scale.

Karen: It appears that the riparian area piece is missing. Elroy: There is a riparian component. Karl: Species, we have riparian species. *Jim:* Riparian areas and national data sets are often not acceptable because of satellite mapping. They are good for matrix communities, but not good for narrow riparian areas. We prefer to use direct measures, but when data are lacking we need to use surrogates. *James*: Getting at intactness through disturbance seems to be a good approach. *Karen:* Roads are in two places in the model. I'm concerned that mining is not included because sand and gravel mining have big impacts. Also certain types of solar energy development use a lot of water. *Karl:* The solar projects currently being permitted are not big water users. From 100s of applications, there are short lists of projects that are likely to be approved. These include only a few dozen projects. Also, they're being screened towards allowing only those that use less ground water. *Karen:* There's so little aquatic habitat in our region, if a proposal is going to make an area dry, managers should know about it. Rebecca Peck: I just saw a proposal for solar that used lots of water. *Charles:* Where development projects may lower ground water tables, we have issues. These should be designated as management areas. We should locate areas for water use questions where groundwater lowering is an issue. *Karl:* Most of the groundwater management questions were dropped earlier in the project due to lack of data.

Jim shows the series of aquatic intactness rollups: the base layers, intermediate results, and final intactness results. *Jim:* In looking at the Aquatic Intactness maps, we think that there are problems with the visuals. They just don't look right. (The results maps are fairly monochrome generally indicating high

intactness). We have issues of 1) needing more data, 2) finding the proper weightings, and 3) the rarity of water in the ecoregion. There's just not enough data to fine tune the model. *Karl:* What if we gave the HUC no score if there are no perennial streams in it? *Jim:* But don't we want to include the ephemeral streams? They support gallery forests. *James*: Maybe combine riparian and aquatic. *Jim*: A possible solution is to put riparian areas in the terrestrial intactness piece with other patch communities and concentrate on perennial streams in regards to aquatic intactness.

Karl: What are the water use units? *Jim:* Acre-feet/year (volume). *James:* Well density data might show distance from riparian zones.

LUNCH

Wildlife Species Conservation Elements

MQ D1 What is the most current distribution of available occupied habitat (and historic occupied habitat if available), including breeding, seasonal habitat, and movement corridors and bottlenecks (as applicable)?

Jim reviewed the resolution from Workshops 3 and 4 that there were three ranked options for pursuing the species distribution questions: 1. Use existing state maps or models; 2. Create a model if there was sufficient occurrence data; and 3. Use SW ReGAP if nothing else was available.

Mountain Lion

Jim showed the process model and discussed data availability. For mountain lion, we used the AZ state GAP map. The coverage was not wall-to-wall as it is for mountain lion using the SW ReGAP model. *Jim* shows the results and two reporting unit versions of the more refined mountain lion modeled distributions (state GAP). He also shows the mountain lion distribution with Elroy's added polygons from his Data Basin review comments, areas where data was missing. *Jim* explains that we cannot add data or change existing data sources. Sabra: This distribution data is not our data (AZGFD). There is conflict data (since 2004). *Elroy* (referring to the SW ReGAP data): If mountain lion covers the whole state, why not use it? *Sabra and Charles*: If you show its distribution over the entire area, then it doesn't mean anything. *Jeff Lovich*: SW ReGAP has Type II error; it overestimates distribution.

Jim showed an attribute and indicator table for mountain lion supported by literature citations. *Jim* noted that the one quantitative indicator in the table for mountain lion was one for a low road density threshold of .6 km/km^2 indicating poor conditions for mountain lion (Van Dyke et al. 1986). The road density value is strict, but it is an indication of where mountain lions will be stressed or run into trouble. *Sabra*: There is no season on them for hunting. We need a time of year when there shouldn't be hunting. But it varies too much geographically. *Jim*: It is easier to find thresholds for habitat specialists than habitat generalists. It is best to have a quantitative threshold, but we have to be careful of regional variation. It does give us a start.

Jim showed the mountain lion distribution plus the intactness layer overlaid (mountain lion status map) using various class breaks to show how it changes the distribution of intact and degraded HUCs. Lions are likely to do better in the high intactness areas (the darker green polygons). In the lighter yellow degraded areas, lions will not be doing as well. There will be more conflict or lions will just be moving through. One could also overlay the distribution of mule deer or sheep. *Christina*: Is status the right word? *Karl*: People get it confused with conservation status (G or S listing). *Jim:* This status piece is a stepping off point for other questions. In addition to overlaying the intactness map with the species distribution, we can change the model by inserting thresholds. *Jim* shows the terrestrial intactness logic model with the invasive species arm discarded as not important to mountain lions and the road density threshold inserted

at the very top of the logic model with an OR operand. By taking the road density threshold and inserting it in the model, the areas of degradation for lions are greatly increased. *Jim* toggles back and forth to show the difference with the earlier map with EMDS breaks. *Jim*: Even if we used the wall-to-wall coverage for mountain lion, using the intactness overlay would help refine it. Even if you don't know any thresholds, this is still a first pass.

Charles is doubtful about the value in this approach. *Karl*: It helps to assess their habitat quality. *Sabra*: It does show habitat degradation or bottlenecks. *Christina*: This is just not the best species to model. *Jeff*: It wouldn't apply to areas without good distribution data. If you have sheep and deer in a mountain range, you are likely to have lion. *Elroy* gives a renewable energy future scenario and says we are punching holes in the remaining habitat. *Jim* recalls the renewable energy changes in the central Sonoran that he showed during Day 1. Eventually that kind of development will impact a range of species.

Golden Eagle

As for mountain lion, *Jim* shows the data sources for golden eagle and the initial HUC and 4 km results for golden eagle current distribution. To assess status, he overlaid the intactness layer with the eagle distribution. *Jim* also presented a slide showing wind development potential and overlaid that with eagle distribution alone and then together with intactness to show conflict areas. It happens that the intact areas are in many cases conflict areas for wind development potential. He shows a detail of the region in California. *Jim*: This is both a regional and a local problem. It is good to be able to look at it at a regional level.

Sabra comments that she has been told that the data aren't available to track movements and migration pathways for eagles.

Big Horn Sheep

Jim starts with the process model for bighorn showing the major data sources from AZGFD, BLM, and USFWS. He shows the initial HUC and 4 km distribution results and a status map with the intactness layer overlaid. The final map sequence shows the AZGFD bighorn sheep density map and FWS critical habitat areas in CA next to the status map. Many of the areas showing sparse bighorn densities are in moderate to degraded areas of intactness. The two areas with medium sheep densities happen to be in areas of higher intactness. *Elroy* notes that some areas of sparse density are due to drought rather than disturbance impacts (such as in the southern part of the ecoregion where there are intact areas and sparse sheep densities?). *Jim*: The leave-behind is not just a report, but maps, ideas, and questions for the future.

Agassiz Desert Tortoise (*Gopherus agassizii*)

Jeff Lovich reminded the group that during the lifespan of the Sonoran Desert REA, the desert tortoise has been split into two distinct species. What we had earlier called the Mojave population is now *Gopherus agassizii* with a range west of the Colorado River, and the Sonoran population is now called *Gopherus morafkai*, representing populations east and south of the Colorado River. *Sabra* notes that Arizona is not using the new naming convention. Jim asks whether we use the scientific names or "western" and "eastern" tortoise.

Jim starts with the process model showing the major data sources to be a MaxEnt potential distribution model of Nussear et al. (2009) that is modified somewhat with the distribution map of Germano (1991). Some of the potential distribution has been deleted from the far western border area of the Sonoran Desert in California. The Nussear et al. distribution was also deleted from areas east of the Colorado River.

Jeff Lovich: There are no native populations west of the Salton Sea and south of Indio. He suggests though that the deleted portion of the MaxEnt model should be put back in in the far northwestern thumb of the ecoregion near Palm Springs.

As before, *Jim* shows the HUC and 4 km results for the current distribution of the Agassiz desert tortoise and the distribution overlaid with the intactness layer for status. The map shows that the bulk of the Agassiz tortoise distribution already falls in the most intact areas.

Todd Esque: You could deconstruct the rollup to show the components, the intermediate and source maps. The system can't do it automatically, but you could explain how to get at the components. *Jim*: You can go back to the source maps also to deconstruct and distinguish between source data and intermediate data output. *Christina*: When you just say status, it makes us think it is a habitat suitability model. She likes the use of *restoration potential*. *Jeff:* There are areas that look like great tortoise habitat, but they have never been seen there. You can classify an area as high tortoise restoration area and not be able to re-establish tortoise. No one has ever successfully modeled tortoise habitat. *Todd*: I would consider the 2009 Nussear et al. model to be successful. There are places that the model shows that tortoises could be and they aren't, but none that the model says they aren't and they are.

Jim: Is the analytical unit appropriate? *Todd* thinks that the 4 km reporting unit is more informative. What about the threshold levels? Is there something simple we could tweak to improve it? Think about it and we can have a call. *Karen*: For tortoise, distance to roads is important because of road kill. It is a significant impact. *Jim*: Will it add information to buffer the roads or is road density sufficient? *Russell Scofield* and *Jeff*: Traffic volume is an important metric, number of cars per day. If there is no traffic density data could you use different road types as a surrogate? *Todd*: The easiest way to recover tortoise habitat is to construct a fence to keep tortoises away from highways. *Jim*: There may not be time, but if we had data on traffic volume, we could buffer roads. Pick a threshold of density and buffer roads based on density thresholds. It would change the classification of the pixels. That is the kind of tweak I was discussing that might make the output more valuable. *Todd*: If they put in proper culverts, the tortoise can pass genetic material under roads. Jim: However, that is too site-specific to incorporate into a model.

Morafka Desert Tortoise (*Gopherus morafkai*)

Jim quickly ran through the distribution of the Morafka desert tortoise, formerly known as the Sonoran population. It is based on AZ GAP data (checked against Germano 1991). *Jim* announced that there is another modeled distribution funded by USGS due out in the next year (checks with Jeff on the time frame). He went on to use this tortoise species as an example for restoration.

Restoration

MQ D3 Where are potential habitat restoration areas?

There were several slides showing mapped extent of various tortoise disturbance factors: transportation network, OHV areas, grazing allotments, fire, and invasive species. There was a discussion about the OHV data. Apparently it was attributed to be too inclusive and should be revisited to delineate areas that are truly for OHV use.

Jim asked a series of questions about restoration. Is it where there are restoration opportunities on BLM land or everywhere? *Karen/Elroy/Karl*: The whole region. *Karen* adds: Both, but separately. *Karl* using solar energy leases as an example: We may have to acquire land to mitigate. Jim: Is restoration driven by connectivity? *Russell Scofield*: It certainly is in California. *Jim*: These questions change how you analyze it. You may be simply improving the condition of where the species already is or you may want to expand their range. We do it differently depending on the question. *Elroy*: The challenge with the restoration question is that in most areas they are talking about treatments. The Sonoran Desert does not really have

treatments. *Karen:* Buffelgrass may be the exception (pull by hand and herbicide). *Jim:* From a species perspective, it could be different. *Elroy*: It is a scale issue. To me, restoration is a local scale issue. *Karl*: What about renewable energy? *Todd*: On the east side the tortoise lives in the uplands and bajadas. They have barriers and isolation but also varied disturbances such as residential and urban development. On the west side they live in the basins, where solar energy development is a problem.

Jim refers to the distribution map for the eastern tortoise. The issue is to maintain good quality of habitat where it exists and some level of connectivity. You wouldn't have to manipulate vegetation. We need to generate the same distribution maps but with priorities overlaid. Go back to the intactness map. We can do it generically or for a particular species. When we game the future, the underlying intactness surface will change. Habitats will be enhanced or degraded based on new information. We need to plan for connectivity early so that we can get ahead of it.

Russell: Restoration activities in California will be in response to T and E listing. *Jeff:* That is a management action. No one has ever restored a big patch of desert. *Elroy*: Most restoration efforts are on a small scale. We simply can't do it across large expanses. Even tamarisk is done on small areas. *Karl:* For restoration, intactness may not work, because it is at too large a scale. What we can change are invasives. *Jim*: I agree, invasives, or altering grazing practices, close a road, stop a lease; these are also restoration. *Karl*: When we first started writing task orders, we were thinking landscape level and invasive species. *Elroy*: Yes, it did start with cheatgrass. *Karl:* Do we really want to answer the question for each species? *Elroy:* I would use it for step-down and maybe later for species.

Russell: It relates to fragmentation also. Can it be tied back? *Jim*: We did fragmentation from the point of view of natural vegetation. We could flip it and look at invasives. Get metrics for spatial pattern. It may give you a picture that we can attempt restoration here, but not there. *Elroy:* We can't assume that if there is a grazing allotment that it is a candidate for restoration. *Karl*: Grazing is a data gap, for usage information or density. *Jim*: If I had animal density information for grazing allotments, I could estimate level of impact and the intactness map would show a higher level of information. *Elroy:* When grazing impact reaches a point, animals are taken off. *Karen*: If we are grazing tortoise habitat and not meeting tortoise needs, we should be changing grazing practices there. *Elroy*: We don't have spatial data to show what impacts are on pastures within allotments. It is hard for us to limit uses if we can't directly tie it to a specific conservation element. *Karen/Ammon*: There are threats to the intact areas that aren't being recognized.

Jim: One more piece before we leave this. This intactness map is not static; it can get rerun at any time. You can make changes and get it turning greener. If this model is worth anything it will also keep track of the improvements as well as the continuing degradation. *Elroy*: Can we put in existing land use allocations? *Jim*: If it is digitally available, yes. *Christina*: Fragmentation isn't always negative. Sometimes fragmented areas are the pieces to restore. *Jim*: From the point of view of invasives, smaller patches may be more restorable. That is different than how we use fragmentation to inform intactness. Running fragmentation models before doing restoration has value. You could say if I were to do this project how would it change the outcome? See what might happen before spending the money. I think that has value.

Since we had spent quite a bit of time on the first five wildlife species and restoration issues, we zipped through the other wildlife species: Lucy's warbler, lowland leopard frog, Le Conte's thrasher, SW willow flycatcher, and Bell's vireo. Data quality varied among the species, but each has a distribution map.

Connectivity

MQ D4 Where are potential areas to restore connectivity?

Jim: Rather than do connectivity for each species (which is huge), we thought we would do as we did in California (with Paul Beier). We did what was called the "magic marker" version that works for a state level or ecoregion view. We identified large landscape blocks and created a friction surface. We had various size thresholds: in the Sierra they were huge; in the valleys and coast range the polygons were smaller. For the first pass, we created a disturbance surface underneath. We created a node in each patch and ran a model that creates a least cost path from patch to patch. Sometimes it is only a pixel wide. We create a swath around the path that is a standard deviation wide. We run circuit theory on top of this. Circuit theory comes from telecommunications to manage interactions. Then we ask, Are any of these connections more important that the others?

Jim shows a slide of linkages in CA and AZ. Those in CA were from the project described above. *Sabra* noted that the linkages in AZ did not look right. She was involved in the project and she did not recognize the map. *Jim* was not sure that we would be able to do connectivity well enough with the budget and time constraints on these REAs. *Russell Scofield/Rebecca Peck*: How will we incorporate new information? Who will add the new data at a later date? *Karl*: With BLM's data portal, we will be able to do it in the future.

Biodiversity Sites

MQ D5 What is the location/distribution of terrestrial biodiversity sites?

Jim noted that biodiversity sites are areas on the landscape that others have deemed important. He noted that there are many partial datasets on the topic, but that The Nature Conservancy is the only entity that did a wall to wall map. The map results show generic polygons, but in Data Basin one may zoom in, use the identify tool, and a name and attribute table will appear for each area. The other dataset used for biodiversity was Important Bird Areas (IBAs) for Arizona from Arizona Audubon Society. *Jim* comments that it doesn't seem adequate to use just these two datasets. There was other data available but none covered the entire ecoregion.

Sabra noted that a new IBA was just completed for Arizona. *Jim*: Can we get it right away? The data we have now is not adequate. *Sabra* said she will check.

Ecological and Cultural Sites

Jim relates the story of producing a national Protected Areas Dataset plus roadless areas and easements datasets. He shows all on Data Basin, first a simple ownership map, the enhanced ownership map and finally special designations as requested by BLM. He notes that some of the designations are stacked because the same piece of land may have multiple designations and it is the most protective designation that shows. *Karl* and *Karen* note that ACECs are missing from AZ. *Jim* says that on the PowerPoint slide perhaps we aren't zoomed in enough. But he will check. *Sabra:* We have a lot to do to improve the data for protected areas in AZ. Many areas are missing. *Jim*: The NCED effort was a first pass. The goal was to try to take the tabular information and make it spatial.

Karl: The REA was not to address cultural sites. All agreed to take off the cultural sites. *Elroy*: The protected area concept doesn't apply to multiple use. If it isn't in a protected area it must be denuded. We are trying to combat that perception. *Jim*: Levels of protection are within the eyes of the viewer. From state to state the same designation may have a different level of protection. We assign GAP codes and IUCN codes to everything. *Elroy*: We were considering having something rolled up regionally. He thinks a lot is missing. He wants management designations as opposed to congressional designations. *Jim* is

going to look for data that Elroy might have sent earlier. The data will be included but kept as a separate piece so that it can be turned on and off. *Jim*: When we add new information, you can do a FRAGSTATS on the designated lands. You can do a management change and rerun the model, overlay HUCs or 4 km grid and get areas of units protected. *Russell:* Some military lands have intact landscapes. Have you worked with that one? *Jim*: That's true, especially back east. Some of the best land is there.

End Day 2.

Wednesday, September 21, 2011

Ecological Systems Management Questions

MQ C1 Where are existing vegetative communities?

MQ C3 What change agents have affected existing vegetation communities?

Jim reviewed the discussion about which of the two main landcover datasets, NatureServe (NS) or LANDFIRE (LF), to use. He noted that we had to use LANDFIRE for those questions that concerned a historic reference condition or a departure from reference since there is no other spatial dataset that represents historic condition. *Jim*: We also used LANDFIRE to show historic and recent disturbances to vegetation communities. For management questions relating to the current distribution of vegetation communities, we decided to use both data sources and let users choose which one is the most appropriate. You will see examples of comparisons between the two datasets.

Creosotebush-White Bursage

Jim showed comparison slides of the NatureServe and LANDFIRE versions of the distribution of creosotebush-white bursage. There were differences between the two: NatureServe showed a more extensive distribution. Brendan, who worked for LANDFIRE in this region, explained that the differences may not be biologically relevant, but more related to the methods used. The differences were likely based on how the communities were classified or how dominance was defined. There was also an insufficient number of training plots.

Jim moved to Data Basin to show how the systems had changed recently and historically.

To show what change agents have affected creosotebush-white bursage, *Jim* begins with the LANDFIRE BpS (Biophysical Settings) layer for that community. This represents the historic or reference condition. For recent disturbance, *Jim* showed a zoomed-in detail of a portion of the ecoregion with examples of recent disturbances shown overlaid on the historic distribution. This dataset was somewhat limited because it did not cover every conceivable disturbance, but it was the only dataset with full ecoregional coverage. The applicable recent disturbance in the Sonoran Desert was mainly fire. For historic change, development, agriculture, invasive vegetation, and vegetation change (conversion to other vegetation types) from LANDFIRE were layered and compared to the BpS reference layer.

He did the same for the paloverde-mixed cactus vegetation community.

Christina: How old is this fire data? *Jim*: This is the severity class data that was shown earlier. *Russell*: Looking at the western edge, the fires look reasonable. *Jim*: Keep in mind that this shows where fires burned this community, not overall.

Jim: What are you expecting to gain from the vegetation community questions? *Elroy*: Try to keep it simple. How much do we have today? How do we tie this to land health assessments? *Jim*: Is the data

adequate to do that? Will there be conflicts with what is actually on the ground and the landcover data? The resolution may not be adequate. *Elroy*: We know that. This will get us in the ballpark.

Dominique Bachelet, specialist in climate change adaptation, was on the phone to help present the climate change results. To add to this discussion on vegetation communities, *Dominique* began with a brief introduction to ILAP, the Integrated Landscape Assessment Project, due to be completed by the end of 2011. She explained the ILAP mission: a group of modelers are looking at trends in fuels, the effects of fire on wildlife habitats and management activities, and priorities to reduce fire risk. Outside of forested areas they are separating C3 and C4 grasses and various shrub types. They are using EMDS and summarizing at the HUC5 scale. It will help to plan for prescribed fire. *Karen Simms*: I attended an ILAP workshop in Tucson. The vegetation is tied to Ecological Site Descriptions. Using LANDFIRE doesn't tie to soil type as well. *Christina*: LANDFIRE is based on existing vegetation; ILAP is based on site potential. But BpS is used to compare to existing vegetation type and as a surrogate for site potential. *Dominique*: LANDFIRE is based on correlation; ILAP is based on mechanisms and trajectories for changes in fire fuels.

Jim: We are looking at existing data, historic and recent disturbance. It doesn't look like enough. Perhaps using what we have in conjunction with ILAP data may work. *Karl:* Maybe it is better to concentrate on restoration with vegetation communities? We need to assess the status of these communities. We want to know where there are large areas of intact vegetation. We have all the pieces; we need a status model for these. ILAP is a bit too late to help us with that.

Ammon: There is a problem with the overall inaccuracies of the large scale data. We are working at the site scale. He says he is going to use soil types and ecological site guides. *Elroy*: You can use the coarser data to help prioritize the site scale work. It's an example of how the field offices might use this data as a starting point and then drill down to a higher resolution. I think we will be able to update as we get more accurate data. *Karl*: Other plot information will be brought in. *Elroy*: NatureServe with their Ecological Systems are working on a crosswalk with Ecological Site Descriptions. *Charles*: Discrepancies come from how the vegetation communities are defined. It depends on which one you use; you have to go by their definitions. SW ReGAP did a formal accuracy assessment and got 80%. That is pretty good. *Christina*: People demand that the pixels match what is on the ground. It is a scale issue. The selling point is Karl's suggestion about landscape intactness. What proportion of these vegetation types are in protected areas?

Jim goes to Data Basin and presents an example of a LANDFIRE vegetation community overlaid with the intactness layer. It gives a high level picture of what percentage of the vegetation community exists in more intact areas. *Brendan*: Are we comparing with reference condition? *Elroy:* I'm not into historic condition. *Ted:* You can use what was there in the past to guide where you are going forward. I would say you need both.

Karen: We are not going to go over soils, but can you tell me how it is going to be used? *Jim* relates what management questions are being answered relative to soils: wind and water erosion and sensitive soils. *Jim:* We haven't thought yet about a wider use of soils. We have the HUC and 4 km results available to mix and match with other results. *Elroy:* Can you use soil maps to try to identify certain vegetation communities? *Dominique*: That assumes you have good soils data, but that is not true. *Charles:* Can you talk about the soils data? *Brendan:* We wanted to use SSURGO but had to use STATSGO as well, which is coarse. Jim Weigand had concerns about STATSGO and gave CBI some additional information. The new maps look more realistic, but they are different than the first round.

Climate Change

Jim started with slides showing the climate change workflow:

- Downscale the regional model from 15 km to 4 km
- Use NCEP National Weather Service records and 3 global models to set the boundary conditions
- Select the parameters of interest (e.g., average annual temperature and total precipitation, seasonal temperature and precipitation)
- Compare the boundary condition results with regional historic conditions (based on PRISM 1969–1999)
- Calculate the differences between historic to future time step for each GCM and each parameter.
- De-bias the results by applying the differences to PRISM historic condition
- Feed future model results into Mapped Atmosphere Plant Soil System (MAPSS) to predict future leaf area index, potential evapotranspiration, potential natural vegetation, and runoff.

Three global climate models (GENMOM [Oregon State University], ECHAM5 [Hamburg, Germany], and GFDL [Princeton]) provide input to explain outside influences to the region. *Jim* shows a slide comparing PRISM and NCEP historic conditions and states that we are using PRISM as a more realistic regional view of historic weather conditions. PRISM was used as the historic baseline within the region, NCEP (National Weather Service) served as the historic condition for the boundary conditions. When compared with PRISM, all the models are starting wetter and ending wetter. CBI de-biased the data to better match PRISM, the regional view. Dominique: We do not do actual bias corrections. We use simple anomaly calculations. We took the change that the model predicted and applied it to PRISM. We are still using the assumptions of the model and applying it to a different baseline.

Jim shows a slide representing how the GCM results are fed into the biogeography model MAPSS. *Jim*: We also wanted to ask, what is the impact on vegetation? We took it a step further by using MAPSS. This will have more value to resource managers than just the temperature story.

Average Annual Temperature

Jim shows a slide comparing PRISM average annual temperature (1968–1999) with each of the global circulation models (GENMOM, ECHAM5, and GFDL) at the two time steps (2015–2030 and 2045–2060) and another showing the differences from PRISM for each model and time step.

Jim: The models don't agree. Climate change deniers interpret that as "they (climate scientists) don't know what they are talking about." But the models use different assumptions at the global scale. Also, the differences in time spans are not additive; they are just comparing to PRISM.

Karl: The bins for temperature are large. It is warming even though it doesn't look like much in the *difference* slides, but it is 1½ –3°C. *Dominique*: That is a lot for a desert.

Average Summer Temperature-Average Winter Temperature

Same slide sequence showing PRISM and the differences. For summer temperature, GFDL is really warm compared to the others. For average winter temperature, all models are in general agreement for the period 2045–2060.

Jim: The take-home message for the temperature results is a short term increase, but greater later (second time step), as much as 3° C over the long term.

Dominique: We only looked at the A2 emission scenario. We didn't want to complicate the story with different emission scenarios. Also, if you had 17 global models, it might be appropriate to do an

ensemble, but you would lose some information. It is better to use fewer models, run each separately and compare the differences between them. Averaging just a few models doesn't mean anything. *James*: Why did you choose these? *Dominique*: We didn't choose. We were told to use the models from Steve Hostetler. It is our first time using regional climate results. It is exciting. ECHAM5 is one of the best. GENMOM is also doing well. It reflects El Niño.

Jeff: Is there a way to find if increased air temperatures will result in increased soil temperatures? Yes. *Jeff*: One potential use is for desert tortoise: sex ratios are determined by soil temperature. A 1.5° increase in temperature may result in no males. *Dominique:* You must also look at vegetation structure for temperature refugia. *Jeff:* It is more complicated for tortoise because they nest in burrows. Have to interpolate soil depth as well.

Average Annual Total Precipitation

Slide showing PRISM, the various models and time steps, and the differences.

There is more variability among the models with precipitation than with temperature. *Jim*: We see periods of drier conditions in the first time period and then precipitation increases somewhat in the later time frame, particularly in the southeast portion. *Dominique*: It is interesting to look at the full trajectory. Think trajectory rather than just snapshots. *Jim*: We were asked to package this as 15 year average snapshots. It is two different snapshots. We don't have information for the time in between; we might miss a drought period in those years.

Average Summer Precipitation

Slide sequence showing PRISM and the differences of various models

GENMOM is drier, then wetter (and also warmer). It could build fuels, but they might burn more. ECHAM5 is considerably drier in the first time step, then somewhat wetter later in the century. GFDL is mixed, wetter, drier. GFDL does not incorporate the monsoon. The results are important for fire occurrence probability modeling.

Average Winter Precipitation

Both GENMOM and ECHAM5 show drier in the winter particularly for the later time step. GFDL is the odd model out showing a mixed bag.

Charles: All differences are relative to the PRISM baseline of 1968 to 1999? Yes. *Ammon*: Both predict compared to PRISM, but not to each other. Correct. *Jeff*: PRISM uses weather stations and interpolates from real weather data. It would be interesting to see how PRISM would compare with on the ground data. *Karl*: Why is GFDL different? *Dominique*: It does not deal well with the summer monsoons.

Climate Change-MAPSS Section (Mapped Atmosphere-Plant-Soil System)

Leaf Area Index (LAI)

As before, the first slide is LAI simulated by MAPSS using PRISM historical climate. The next slide shows the change in LAI for the 3 global climate models (GENMOM, ECHAM5, and GFDL) over the two time steps compared to PRISM (1968–1999).

GENMOM shows small decreases in both time periods. ECHAM5 a decrease and then slight increase.

Dominique: MAPSS uses long-term average climate data to determine the amount of water available for vegetation. The hydrology model looks at the water budget. During the driest month of the year all of the

water in the soil profile is used by the vegetation that is there. They use competition algorithms for trees and grass, corresponding with what plants do with available water during the driest month of the year, and calculate LAI for the driest month. It gives an idea of vegetation density. The southwest region has a low Leaf Area Index (LAI). LAI is higher at higher elevations or in a region like the Pacific Northwest.

Potential Evapotranspiration

GENMOM shows uniform increases in evapotranspiration. ECHAM5 shows greater evapotranspiration mid-century. With drier and warmer conditions, there will be an increase in evapotranspiration. The vegetation is a conduit for moisture from the soil to the atmosphere.

Runoff

The models show an increase in runoff. Increased runoff means less water uptake by plants.

Potential Vegetation

Jim explains that the plant communities are global functional communities. There are only 56 classes for the world. We have to try to fit our local vegetation into those general categories. Also, this is potential vegetation that would be present if humans were not. It does not reflect the desertification process from human influence, so some of the categories like grassland do not seem to fit today's vegetation classes. Someone describes during the time of Spanish exploration, the grass was belly high to a horse.

GENMOM shows C4 grasses expanding their range because they are better adapted to higher temperatures.

Jim explains the *differences* maps. No color means that the vegetation will stay in the same class. Colored pixels or polygons mean that vegetation will experience a major change to another class. *Elroy*: Will we have a cheat sheet, a crosswalk table in the report? Yes, there will be crosswalk tables. *Jim* shows a slide with a table listing changes in number of pixels for various vegetation classes. These places identify for change, no matter what is on the ground now. It has value in providing context and a trajectory of getting more grassy, or shrubby or just moving to a leaner system so management has to be more cautious.

James: Are there thresholds to discriminate when things go from one class to another? *Dominique*: We can calculate thresholds in LAI to separate broadleaf from conifer for example. There are thresholds that are inherent in the models. *James*: It will be important to have a description of the thresholds to use for the interpretation of results. ECHAM5 shows big changes in the west. *Dominique*: Yes, they will be in the report.

Uncertainty Associated with Climate in the Biogeography Model

Dominique: The estimation of the intensity of uncertainty is unitless. The first two images on the slide show uncertainty estimates for interannual variability in temperature and precipitation between 1968 and 1999. The greater number of meteorological stations, the better. There is higher uncertainty at higher elevations and with greater topographical relief. The darker colors mean higher uncertainty. Dominique explains that the interannual variability in temperature is relatively low and that there is greater variability in precipitation.

Jim: Tell us why there are separate maps for precipitation and temperature. *Dominique:* There are separate maps for each because all weather stations do not give both temperature and precipitation. There are also separate maps showing a representativity index for both temperature and precipitation and one for vertical and horizontal distance. The vertical and horizontal distance map gives an indication of how close we are to weather stations.

Jim: Of the various GCMs that Steve used, do they all treat oceans the same? *Dominique*: They all come from different assumptions and different initial conditions. They have to take into account cloud formation. Most GCMs have an ocean component.

James: We are already on the trajectory for the A2 scenario. *Dominique*: Yes, we are exceeding that. The current trajectory is approaching A1FI (fuel intensive). But we are using A2 in the modeling. *Karl:* The Sonoran precipitation: it gets drier first part of the century, then gets wetter. *Dominique*: Yes, really dry in the 2020s, then wetter. We're waiting for 2020 to see if our fire models are right. Then after 2075 back to hot and dry.

Dominique: Vegetation should have a feedback to the atmosphere. Regional climate models get into more detail, but they don't deal with fire impacts. *Christina*: If you have greater moisture in the atmosphere and not tied up in ice, you could have greater precipitation for a time. *Dominique*: Yes, especially since we don't understand how ice melting will affect cloud formation.

Jim: How will we use all of this? We will provide all of the content. For application to management questions, simpler is better. We will focus on a few big stories. We will pick the best one for the report and put the rest in the appendices. We will use ECHAM5 as the best representation of the monsoon. We can say where are places at the HUC level where we will see more change, where on the landscape will we expect the greatest changes in temperature and moisture, and then communicate some aspect of uncertainty.

Christina: Will we combine with conservation elements? *Karl*: We talked about that early. We're not going to predict range changes. Change in temperature and precipitation overlaid with tortoise distribution map: where the greatest changes are is where the tortoise is most vulnerable. *Jeff:* My reaction to what you just said is that simplifying complex processes is a little frightening. Capturing the variability and discordance is important. *Jim:* Yes, that's true. We could do the same thing for all three models. We'll do this (showing the slide of all the models in the same frame), but then in the text when applying to MQs we'll use ECHAM5.

Christina: Overlay with species and protected areas; include National Parks and wilderness areas. *Jim*: All these places are designated for all kinds of reasons. Early parks were set aside for their features. The Everglades for example is vulnerable to salt water intrusion. That is a good exercise. How will special areas be affected? *Christina*: To what extent will areas be refugia for climate change? Maybe not!

Final Report Outline

The group turned to a discussion of the outline for the final report. *Karl* presented the original outline draft and a second version offered by Craig Goodwin. The discussion centered on how to optimize readability and utility while at the same time controlling the prodigious quantity of material. *Karl* said that an encyclopedic approach could produce a 1000 page report. He suggested that much of the material be put into appendices that would be searchable. *Karl* would like to keep the body of the report at 150 pages. We want the report and appendices to be useable by both GIS and non-GIS users.

There is some discussion about summarizing the results in the body of the report. *Jim*: The Executive Summary is the hardest part of a report to write. He is afraid that the entire report will be an executive summary which will be harder than writing more pages. It is not doing us (the contractors) a favor by shortening the report in this way (making it more condensed and interpretive). Shortening the paper may actually increase the workload. *Karl*: We are not trying to lighten the load, although that would be good, but mainly to make it the most useful to BLM and other users.

We are planning a crosswalk between the conservation elements, change agents, and management questions. *Bill Lamb*: You will have to be careful. There will be many skeptics. A crosswalk is great.

What does the model do, what are its limitations? *Karl:* Data gaps and uncertainty at each step. *Jeff*: A painfully developed executive summary is necessary.

Sandy Bryce: Each region has its top issues that can form case studies for the body of the text. In the Sonoran, of course desert tortoise will be one and renewable energy and maybe tamarisk. There will be a hierarchy of presentation with the featured stories and then a shorter summary for the rest. *Jim* added that a similar format or template would be used for the summarized elements. He also mentioned a flow chart to point to areas of interest.

James: What is the most useful to the field offices? *Jim*: The report has multiple users from BLM field office staff to managers to the public and politicians. *Ammon:* Most important is having access to the data. *Elroy*: We don't want to get the cart before the horse. How do we step this down to planning? How it will be used will vary. The report won't lead directly to management decisions that we need to make, but the information will help. *Karen*: In preparing a broadscale land use plan this will be helpful to guide management strategies. We are emphasizing cross-jurisdictional planning. Ecoregional review is helpful. There is applicability to EA and EIS analysis. *Karl:* The REA report is not a decision document. It is an informational tool. *Jeff:* We would bring in our publication department to ask them for ideas on how to handle such a massive amount of information.

Karl points to Chapter VI Management Recommendations, approach to ecoregional direction (or step-down). **Dynamac note**: By definition this chapter will require BLM input. *Elroy*: Managers will take it to resource scientists. I will find it on my desk. *Christina*: I am nervous about step-down. This report provides context. Is that cover type under greater threat or does it have a greater degree of landscape intactness? *Karl*: State directors' council will take reports to look across state lines. Work with LCCs and other partners to set goals and objectives for the ecoregion.

A good thought to finish on.

End of Workshop.

Day 1

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Day 2

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