*Please write your name on the back of the blue book, not the front. Write responses in the blue book. You are allowed only a writing utensil and eraser. This exam is closed-book, closed-notes, no-calculator, and no other digital technology. Essays must be in grammatically correct full sentences that are well-organized into paragraphs. For the essays, Grade of C requires answers that are mostly correct; grade of B requires answers that give correct details and refer to the literature; grade of A requires answers that give correct details, refer to the literature, and go in depth in a creative & elegant manner.*

**Part A** *20 points = 10 answers @ 2 points each*

In the crosstabulation table below, bold are the table’s labels and italics are numbers of pixels. Column 1 is non-developed for the dependent variable, column 2 is developed for the dependent variable, row 1 is category 1 of the independent driver variable, row 2 is category 2 of the independent driver variable, row 3 is category 3 of the independent driver variable. Compute the following:

1. empirical probability of developed for independent driver category 1
2. evidence likelihood of developed for independent driver category 1
3. empirical probability of developed for independent driver category 2
4. evidence likelihood of developed for independent driver category 2
5. empirical probability of developed for independent driver category 3
6. evidence likelihood of developed for independent driver category 3

**Category 1 2 Total**

**1** *0 10 10*

**2** *30 20 50*

**3** *10 30 40*

**Total** *40 60 100*

1. Under what conditions would all the empirical probabilities be equal to each other?
2. Under what conditions would the sum of all the evidence likelihoods equal to one, i.e. 100%.
3. If a modeler were to use empirical probabilities as suitability values, then what would the suitability values indicate about the quantity of future change?
4. If a modeler were to use evidence likelihoods as suitability values, then what would the suitability values indicate about the quantity of future change?

**Part B** *20 points = 10 answers @ 2 points each*

1. Explain the difference between inductive and deductive.
2. Explain the difference between pattern and process. Pattern describe the data for example, the patches in land change or the curvature of a hurricane while the process is the describes the mechnsm the creates the patterns. In land change we could look at agriculture, builing, mining, etc
3. Explain the difference between calibration and validation. Calibration use the data to set the model parameters, example if you have to points, a the slop and and intercepet can be drived by drawing a line through the points while Validation is use the mathematical relationship on data that was not used in the calibration. This test the degrees to which the prediction differs from the model.
4. Explain the difference between stochastic and deterministic.
5. Explain the difference between ex-ante assessment and ex-post assessment.
6. Explain the difference between prediction and explanation. Prediction is one thing that you think is more likely to occur.eg. deforestation, while Explanation is
7. Explain the difference between normative and positive.
8. Explain the difference between pattern validation and structural validation.
9. Explain the difference between equifinality and multifinality.
10. Explain the difference between prediction and scenario. Prediction is one thing that you think is more likely to occur.eg. deforestation, while scenario is a story told in the form of number, maps or words about how the future would be.

**Part C** *10 points = five answers @ 2 points each*

Respond TRUE or FALSE concerning whether Brown et al. (2013) made each of the following recommendations:

1. Modelers should align model choices with modeling goals. True
2. Modelers should aspire for greater predictive accuracy because greater accuracy will result in models that will lead to efficient policies for environmental sustainability. FALSE
3. Modelers should integrate land change models with observational data, across scales, and across positive and normative modeling approaches.
4. Modelers should collaborate to develop one comprehensive model that all scientists should use to facilitate cross-case comparisons. False
5. Modelers should improve and disseminate use of model evaluation approaches. True

**Part D** *20 points*

How should modelers use the various features of the TOC curve and its AUC to make decisions?

The ToC curve shows the dependent variable eg forest change and the independent variable eg distance. The Xaxis and axis are the Hits and Hits + False alarms of the Extent. The Area under the Curve equal 1 and the horizontal linear line divide the area into two parts, the area below the cureve having less than 0.5 and greater than 0.5 above the line. The Toc curve indicate the categories that that are ranked based on their suitable value for change. The curve starts from the the lower left corner with the highest ranked category to the lowest in the upper right coner. The line that connect each category is called the segment, and the length of the segment shows the size of the category in the spatial extent. The steepness of the segment above the linear line indicate that the instensity of change in the category. The shape of the TOC also shows the patterns of the in the data. If the pattern in the data are constistent through time, theTOC curve will be linear as the original line. However if there is non stationarity in the data, the

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**Part E** *10 points*

What is the difference between a process-based model and a pattern-based model? Give an example of a pattern-based model. Give an example of a process-based model. What are the advantages and disadvantages of process modeling compared to pattern modeling?

Definition: Process-based models focus on simulating the underlying mechanisms, interactions, and that drive the system being modeled. These models aim to capture the cause-and-effect relationships within a system. Example: hydrological model that simulates the movement of water within a watershed, considering factors such as rainfall, evaporation, infiltration, and runoff. These models use equations that represent physical processes to simulate the behavior of water flow in the landscape.

Advantages of Process-Based Models: They offer a detailed understanding of system dynamics. They are based on fundamental principles, allowing for better predictive capabilities. Useful for understanding how changes in variables affect the entire system.

Disadvantages of Process-Based Models: They often require detailed data, which might not always be available. They can be computationally intensive. The precision and complexity might lead to difficulties in model calibration and validation.

Pattern-based models focus on identifying and replicating observed patterns or behaviors in the system. Rather than emphasizing underlying mechanisms, they focus on recognizing and predicting patterns based on available data. Eg GEOMOD, LCM (DF,SWM). these models learn patterns from vast sets of labeled images to classify or recognize objects.

Advantages of Pattern-Based Models: They can work well with large and complex datasets. They can provide predictions or classifications without the need for a deep understanding of underlying mechanisms. They can be computationally efficient.

Disadvantages of Pattern-Based Models: They might lack explanatory power about the underlying system mechanisms. They might struggle with extrapolation outside the observed patterns. They can be sensitive to biases or noise present in the data used for training.

**Part F** *20 points*

What are the most important messages from the book chapter Pontius et al. (2018) entitled *Lessons and Challenges in Land Change Modeling Derived from Synthesis of Cross-Case Comparisons*?

Answer: **Abstract** This chapter presents the lessons and challenges in land change modeling

that emerged from years of reflection and numerous panel discussions at scientific

conferences concerning a collaborative cross-case comparison in which the authors

have participated. We summarize the lessons as nine challenges grouped under three

themes: mapping, modeling, and learning. The mapping challenges are: to prepare

data appropriately, to select relevant resolutions, and to differentiate types of land

change. The modeling challenges are: to separate calibration from validation, to predict

small amounts of change, and to interpret the influence of quantity error. The

learning challenges are: to use appropriate map comparison measurements, t

o learn

about land change processes, and to collaborate openly. To quantify the pattern validation

of predictions of change, we recommend that modelers report as a percentage

Conclusion

All 13 of the models are wrong in the

respect that the outputs have errors. Errors in pattern validation mean that the patterns

extrapolated from the calibration time interval were not stationary with the

patterns observed during the validation time interval. These errors are a reflection of

the landscape as much as they are a reflection of the model. If the scientists interpret

the results in a useful manner, then scientists can learn; and if scientists learn from

a model, then the model was successful at advancing science. It is essential to use

measurements that can be interpreted with respect to a model’s intended purposes in

order to facilitate learning. Clarity and rigor are necessary to establish procedures

and measurements for informative judgments concerning model performance. This

chapter illuminates common pitfalls and offers guidance for ways to overcome the

pitfalls. Specifically, we recommend modelers report the sizes of misses, hits, wrong

hits, and false alarms. Those four measurements are based on the mathematical

ideas concerning the intersection of sets, which are regularly taught to elementary

school students. If scientists meet the challenges specified in this chapter, then we

are likely to learn efficiently, because meeting these challenges can help scientists

prioritize a research agenda for land change science.

DEFINITIONS

* Interpolation fits a mathematical relationship through data points.
* Extrapolation extends the mathematical relationship beyond the data.
* A Parameter is a variable that determines how the mathematical relationship behaves.
* Calibration uses data to set parameters.
* Validation measures how the mathematical relationship fits data that was not used for calibration.

Can humans influence the path of the hurricane? No, the   
What decisions will people make based on the output of this predictive model? When and were to evacuate to, help people

Can humans influence the path of land change?  
What decisions will people make based on the output of this scenario model?

Fist step in modellig is to decide the goal

1. Predictive modeling
   1. The goal of predictive modeling is to portray the future that is destined to occur.
   2. Model validation helps to understand how much trust we should have in the prediction.
   3. Predictive modeling is helpful when it includes an assessment of the level of trust that the audience should have in the model’s output.
2. Scenario modeling
   1. The goal of scenario modeling is to facilitate a conversation among stakeholders and decision makers.
   2. Scenarios allow people to see the implications of their storylines assumptions.
   3. Scenarios allow people to prepare for various possible futures.
   4. Scenarios allow people to expand the way they think about the options for how to influence the future.
   5. Scenario modeling is helpful when it allows people to make better decisions concerning how to influence the future.

GEOMOD AND ASSESSING VALIDATION

Geomod requires one map which is used as the beginning time for calibration, and two, the year we are extrapolating to. It uses four decision rules; the suitability map, neighborhood constraint, regional stratification, and persistence of the landscape to determine if a pixel is a candidate for change. The variable provided determines the suitability map which shows the spatial allocation of the pixels that are candidates for change.

After running the simulation, you can assess the validation of the predicted map by conducting a crosstab between the predicted and the reference map of the year you are predicting to show agreement. The off-diagonal show disagreement between the simulated and reference, while diagonals as the agreement.

Geomod’s method to compute suitability is Inductive because it looks for patterns in the data

Geomod is decductive because it uses constraints and neighbourhood constraints to formulate theory of the process which is used in the simulation

Questions in Class

* What types of decisions would humans make based on each type of simulation?

FEMA use it for evacuation purposes, Companies that buy carbon credits, conservationists, etc

* How should the simulation of a hurricane differ conceptually from the simulation of land change? Predictions of huricanes might be more difficult, because when it hit in the sea, we are uable to control it, while predictions in land change is morecontrollable.
* What types of decisions would humans make based on each type of simulation? FEMA use it for evacuation purposes, Companies that buy carbon credits, conservationists, etc
* How should the simulation of a hurricane differ conceptually from the simulation of land change? Predictions of huricanes might be more difficult, because when it hit in the sea, we are uable to control it, while predictions in land change is morecontrollable.
* Is a Recent Trends Scenario a prediction? No
* Is it possible to make a Recent Trends Scenario when you lack knowledge of the processes? I think you necessarily need to know the process, all you need if the storylie cos=cerning the disctintive process like what NELF has
* Can humans influence the path of the hurricane? NO, these are natural occuraence and out the reach of man.  
  What decisions will people make based on the output of this predictive model? FEMA use it for evacuation purposes,planning, utitltiy network planning, etc
* There are 3022 pixels of gross gain during 1971-1985.
* How many pixels of gross gain should we extrapolate during 1985-1999? 3022 piexls
* Geomod’s constraint allows for a deductive feature. If you have a theory that people build near previous built, then you run the model in constrained mode regardless of what the data show. This theory required 5 seconds to create.
* Geomod’s method to compute the suitability map is inductive. Geomod has no theory of why builders target some elevations and avoid other elevations. Geomod computes the empirical pattern then extrapolates the pattern.
* Is Geomod a verified model? If Geomod behaves as Geomod’s documentation claims then Geomod is verified.
* Is Geomod a valid model? It does not make sense to state that a model is valid or not. It makes sense to test the validity of a particular simulation for a particular application and combination of parameters.
* If the calibration time interval uses an irrelevant variable, then pattern validation will find that the extrapolation is not valid.
* If temporal non-stationarity causes the pattern during the calibration time interval to differ from the pattern during the validation time interval, then pattern validation will find that the extrapolation is not valid.
* How should we assess Geomod’s run1 validation for Assignment 2? The simulated quantity of built gain for run 1 derives from extrapolation of linear interpolation through 1971 and 1985.
* Which color(s) are the simulated change? Yellow and Red, meaning False Alarms and Hits.   
  Which color(s) are the actual change? Green, Blue, and Red, meaning Actual Built Loss, Misses, and Hits.  
  Why are False Alarms larger than Misses? The size of extrapolated change is larger than the size of actual change.  
  What is the result of this run’s validation? Hits are fewer than the sum of False Alarms and Misses.  
  What is the result of Geomod’s verification? Geomod performed as advertised.
* False Alarms and Misses are validation errors. Run1 specified the quantity and the allocation.   
  Is the incorrect quantity or incorrect allocation responsible for most of the error?  
  Quantity error = |2787 - 2511| = 276 < 5022 = (2787 + 2511) – 276 = Allocation error.