Abstracts of Presentations

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Construction and Engineering Auditorium

LaSells Stewart Center

Monday, June 15

3:00 – 4:45 Analysis of Stream Networks

Patterns of coho salmon size and survival within a stream network

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Effective habitat restoration planning requires correctly anticipating demographic responses to altered habitats. Network-scale investigations of habitat-specific growth and survival of juvenile salmonids have provided critical insights that can now better inform and help prioritize rehabilitation activities. Using habitat-specific growth, survival and movement data from PIT-tagged coho salmon (*Oncorhynchus kisutch*), we illustrate the potential benefits of spatially-explicit habitat restoration scenarios in an Oregon, USA coastal basin. Use of in-stream antenna arrays, remote scanning of PIT-tagged fish, and multiple recapture efforts allowed us to document seasonal movement, growth and survival throughout a 67 km^2 basin over 4 years. We used hierarchical linear models to evaluate network patterns of juvenile coho salmon abundance, size, and survival rates. We found that under present conditions, survival and growth are greater in tributary habitats compared to downstream mainstem habitats. Intermittent tributaries are particularly important as seasonal refuges and provide valuable spawning and foraging habitats. Under potential restoration scenarios, the greatest benefits, in terms of sensitivity of juvenile coho salmon population abundances, are likely to be observed in the mainstem. These findings highlight the value of habitat-specific demographic data to restoration planning, and the usefulness of individual-based approaches for fish population monitoring at whole-basin scales.

NetMap: Linking data and streams

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This is a talk not so much about data analysis, but about linking data sources to provide something to analyze. Stream systems present interesting challenges for discerning cause and effect. The downhill and downstream flow of water and water-carried materials through an ever converging network of stream channels acts to convolute effects of spatially and temporally disparate processes. The signals we ultimately observe – channel conditions, habitat abundance, fish use – area a consequence of these interactions, and it is not obvious how to de-convolve the signal; that is, how to discern relationships between observations separated in space and time. One approach is to consider the processes involved. Many years of research have gone into development of conceptual models of basin hydrology and geomorphology. These models provide a basis for identifying, conceptually, the factors that create and alter the conditions we see. Being geomorphologists, we have tended to think about these factors in terms of material fluxes; where does what we find in a channel come from and how did it get there? The trick then is to find data, and ways to use that data, that characterize the source and transport mechanisms for water, sediment, wood – whatever we find. For many landscape attributes, we now have a wealth of spatially explicit information: elevation, land cover, soils, geology, climate; we have a wealth of channel data; and we have a wealth of numerical models and computational power for doing things with all those data. NetMap is the result of our efforts to combine these things to elucidate relationships between stream

networks and the landscapes they drain. NetMap consists of a digital watershed database and analysis tools, run through ArcGIS, that link and summarize landscape and channel attributes from a geomorphic – flux-based perspective. The spatial framework is based on surface flow routing: all points and all channels are explicitly linked. Data structures are designed to serve as inputs to and accept outputs from other models: habitat intrinsic potential, wood recruitment, landsliding, surface erosion from roads, thermal loading. These tools allow us to combine and juxtapose data in useful ways: to compare stream reaches, to compare basins, to compare process rates, and to compare scenarios. I will illustrate the use of NetMap, and show how to obtain the datasets and tools.

A Moving Average Approach for Spatial Statistical Models of Stream Networks

Jay M. Ver Hoef [1] and Erin E. Peterson[2]
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In this talk we show how to use moving averages to develop new classes of models in a flexible modeling framework for stream networks. Streams and rivers are among our most important resources, yet models with autocorrelated errors for spatially-continuous stream networks have only recently been described. We develop models based on stream distance rather than Euclidean distance. Spatial autocovariance models developed for Euclidean distance may not be valid when using stream distances. We use spatial moving averages to build several classes of valid models for streams. Various models are derived depending on whether the moving average has a tail-up-stream, tail-down-stream, or a two-tail construction. These models can also account for the volume and direction of flowing water. Example data for this talk come from various rivers in the United States and Australia. We model variables from water chemistry to fish abundance in a spatial linear model that allows us to estimate fixed effects and make spatial predictions. One interesting aspect of stream networks is the possible dichotomy of autocorrelation between flow-connected and flow-unconnected locations. For this reason, it is important to have a flexible modeling framework, which we achieve by using a variance component approach.

Is the Range Parameter a Measure of Patch Size in Headwater Streams?

Nicholas A. Som and Lisa M. Ganio, Department of Forest Ecosystems and Society, Oregon State University

Patchiness and the structure and scale of patches are important features of ecological systems. In particular, patches are integral to the landscape view of ecology. Landscape ecology often uses geostatistical approaches to predict responses over the landscape or to describe patterns of response variables. It is common to find the geostatistical range parameter used to quantify patch size in terrestrial and aquatic systems. But this has not been justified and it has been questioned. In this study we use a collection of 40 randomly selected headwater stream basins in western Oregon, in which the number of fish in every pool was recorded, to investigate the relationship between the size of patches of fish and the statistical range parameter and a similar statistic, the integral range. Preliminary results indicate that range parameter is not associated with patch size. While the integral range is more associated with patch size than the range parameter, the association is not strong. We provide some ideas for why this is so and suggest conditions under which an association might be expected.

Tuesday, June 16

8:00 – 9:45 Spatio-Temporal Bayesian Hierarchical Models for Environmental Data

Spatial Hierarchical Modeling in Comparing Extreme Precipitation Generated by Regional Climate Models

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Using a spatial Bayesian hierarchical model, we analyze precipitation output from six regional climate models (RCMs). The primary advantage of this approach is that the model is designed to borrow strength across location by means of a spatial model on the parameters of the generalized extreme value distribution. Being that the data we analyze have a relatively short time span for characterizing extreme behavior but have great spatial coverage, this is particularly important. The hierarchical model we employ is computationally efficient as we have data from nearly 12000 locations. The objective of our analysis is to compare the extreme precipitation generated by these RCMs. Although the RCMs produce similar spatial patterns for the 100-year return level, our results show that their characterizations of extreme precipitation are quite different. We also found differences in the spatial patterns for the point estimates of the extreme value index. These differences, however, may not be significant due to the uncertainty associated with estimating this parameter.

Bayesian Inference for Marine Mammal Telemetry Data: A Continuous-Time Approach

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Marine mammal telemetry data is obtained by determining the location of an animal in space at several points in time. The observed locations are function of two important factors, true location and measurement error. In order to handle the fact that most telemetry data is collected opportunistically on an irregular basis we consider a movement model stochastic process in continuous time. Using this approach likelihood can be formed using the raw data instead of aggregated, thinned, or interpolated data. Bayesian methods are explored for making inference on animal locations as well as other movement quantities of interest, such as travel speed and habitat use. The Bayesian inference paradigm allows for inclusion of parameter uncertainty in location estimation, as well as, propagation of uncertainty through nonlinear relationships in the movement parameters of interest. Several model extensions which we are investigating will be discussed. These include change-point models, for making inference on behavioral shifts, and a model for detection of measurement error outliers.

Simultaneous Cellular Movement Models for Resource Selection

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In recent times, ecologists are finding themselves with an overwhelming amount of data from which to use in modeling efforts and make scientific inference about the natural system under study. Animal ecologists in particular are readily collecting nearly continuous spatio-temporal data on animal locations

via global positioning systems and other satellite telemetry technology. In addition, there is a wealth of readily available, complex environmental data via geographic information systems. Though numerous modeling approaches have been proposed (and used successfully) for studying the relationship between animal locations and their environment, many are self-admittedly oversimplified or computationally infeasible in high dimensions. Given that computational implementations of all continuous models must be discretized on some level, we propose a framework that mimics the discrete spatio-temporal processes directly. This method allows for the statistical modeling of dynamic spatio-temporal movement behavior while remaining computationally tractable in high dimensions (e.g., simultaneously modeling several distinct individuals).

Issues with Modeling Spatial Ordered Categorical Data

Megan Higgs , Montana State University

Ecological or environmental monitoring may produce ordered categorical data collected at point-referenced spatial locations. A Bayesian hierarchical spatial model is introduced that relies on the use of a latent Gaussian random field and the notion of clipping the underlying continuous distribution to obtain a categorical random field. Practical issues involved with parameter estimation and obtaining predictions at new locations are discussed and investigated via simulation. The method is applied to predict a surrogate measure of stream health in Montgomery County, Maryland. I also suggest a possible extension to the model for the purpose of estimating the change in the mean of the categorical random field over time.

10:15 – 12:00 Relationships between Landscape, Habitat, Stream Condition, and Fish Populations

Goldilocks and the three pools: do juvenile salmon choose habitats that are "just right"?

Marti J. Anderson[1] and Russell B. Millar[2]
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Interest lies in the development of quantitative models to relate densities of juvenile coho salmon (*Oncorhynchus kisutch*) to a suite of habitat variables in Oregon coastal freshwater ecosystems, to aid in the environmental monitoring and management of this species. Typically, generalised linear models (GLMs) are used to model the relationship between a given species and a number of environmental variables. However, the responses of species to environmental gradients tend to be non-linear (often unimodal), asymmetrical, heterogeneous (showing more variability where organisms are more abundant) and zero-inflated. Heterogeneity is also caused by there being multiple limiting factors on densities which act simultaneously in a given environment. We propose to investigate the habitats occupied by salmon using a multivariate approach. Looking at things from the perspective of the salmon, we intend to compare directly the variability of habitat characteristics for sites where coho occur in larger *versus* smaller or zero densities. Preliminary analyses suggest that the habitats preferred by juvenile coho are distinguishable by virtue of their specificity, which may explain why GLM approaches fail to achieve much predictive power. Like Goldilocks, juvenile coho may seek out habitats that are "just right", which may be in the middle of the range with respect to a host of potential simultaneous limiting factors. In this context, non-linear quantile regression splines may be used alongside multivariate methods to characterise (and parameterise) the habitats distinguished by having enhanced coho densities.

Addressing redundancy of information in habitat metrics to refine understanding of juvenile-habitat associations for Oregon's coastal coho salmon (Oncorhynchus kisutch)

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ODFW has provided a large, rich and well-documented dataset for juvenile salmon and habitat features in Oregon's coastal coho range. I would like to investigate the relationship between juvenile density and habitat features. I use ordination methods to perform an exploratory analysis of the habitat dataset. There are more than 30 habitat variates, several of which are closely related, e.g. the number of deep pools versus the total number of pools at a site. I first show a correlelogram for all of the variates and highlight the patterns present in the raw data. I then show an ordination analysis and evaluate the effectiveness of ordination tools for summarizing the habitat information and reducing redundancy of information. I conclude with a preliminary regression analysis for coho density versus habitat.

The effect of uncertainty in monitoring data on status assessments for Snake River Spring/Summer Chinook salmon

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We have developed a simulation model that describes the effect of uncertainty in monitoring data on the ability to correctly assess the ESA status of Snake River Spring/Summer Chinook salmon populations. The model is based on the population viability criteria established by the Interior Columbia Technical Recovery Team, simulated population and habitat condition time series, and viability criteria specific measurement and classification error dependent on monitoring effort or method. Using the model, resultant status assessments can be simulated for different types of monitoring programs under various scenarios of salmon abundance, productivity, spatial structure and diversity. We will discuss the results of our work and, more generally, the concept of evaluating data quality and decision criteria using a simulation approach.

A comparison of spatially explicit landscape representation methods and their relationship to stream conditions

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In this study, we compare a variety of metric types that can be used to represent landscape condition: non-spatial Lumped metrics (i.e. % grazed or forested areas), inverse-distance-weighted (IDW) metrics based on distance to the destination (stream or the stream outlet), and a new modified IDW metric that accounts for proximity to the destination *and* the level of hydrologic activity (HA-IDW). We use an information-theoretic approach and an extensive freshwater dataset collected in Southeast Queensland, Australia to compare the ability of the metric types to account for variability in 15 freshwater stream indicators. The indicators belong to four general categories: Fish, Invertebrates, Physical/Chemical, and Ecosystem Processes and were collected during two seasons. Our results showed that there was no one metric type

that was more suitable for modeling streams data. Though, Lumped metrics rarely performed as well as other metric types, regardless of indicator or season. Patterns in metric performance did emerge for some indicator categories. Metric types based on flow length to the stream (IDW and HA-IDW) were more suitable for modeling Fish indicators, while models based on the HA-IDW metric using distance to the stream outlet generally outperformed other metric types for Invertebrates; these results did not vary by season. For the Physical/Chemical indicators there was weak evidence that a HA-IDW metric model generated using distance to the stream performed better during the post-wet season, while there was more support for a metric model based on distance to the stream outlet (IDW or HA-IDW) during the dry season. No patterns were apparent in the Ecosystem Processes indicators. This evidence suggests that more spatially explicit methods of landscape representation must be considered in order to thoroughly study the relationship between landscape, habitat, and stream condition. There are clearly influential landscape areas that have a disproportionate effect on stream condition and the extent and location of these areas may differ depending on indicator category and season. Although these data were collected in Australia, we believe that these results may be generally applicable because they are corroborated by a handful of studies undertaken in the US.

1:00- 2:45 Terrestrial Surveys

Modeling Trends in Vegetation With Ordinal Cover Classes: Implications for Long-Term Monitoring Designs.

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There are many environmental sampling situations that involve the collection of ordinal response variables. One widespread application is found in the visual estimation of vegetation cover in discrete classes. When evaluating such data potential problems exist in the analysis of trend because it is not clear how well an ordinal structure reflects changes in the underlying unmeasured percent cover variable, a continuous proportion. Often categorical cover data are treated as continuous with normal or log-normal error distributions and analyzed with ordinary least squares (OLS). The validity of this approach has not been well tested and guidance on this issue is lacking for Ecologists. An alternative approach, proportional odds logistic regression (POLR) directly embraces the categorical response structure but has not been widely applied in this context.

We explore the power of OLS and POLR models to detect linear trend via Monte Carlo simulation. Technically, the latent variable in a POLR model follows a Logistic distribution (Agresti, 2002). However, we believe a more realistic approach to assess power to detect trend is to define a logit transformed Beta random variable as the latent variable. This is a more flexible method, allowing for symmetric and asymmetric distributions common in vegetation data. Also, the logit-Beta latent variable provides a link back to the unmeasured percent cover variable yielding some insights into the relationship between the ordinal and continuous measures of vegetation cover. We compare both latent variable distributions (Logistic and logit-Beta) to explore the influence of asymmetry on power to detect trend. We also consider if the distribution within discrete cover classes influences the choice of which model (POLR or OLS) is more appropriate. The implications for a National Park Service sagebrush steppe vegetation monitoring project in the Upper Columbia Basin Network are discussed.

Stream temperature standards & timber harvest - How are we doing?

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The Oregon Department of Forestry's Riparian Function and Stream Temperature project, largely designed to assess the effectiveness of forestry regulation at protecting stream water temperature in the Coastal Range, is halfway to completion. We report stream temperature responses one and two years post-harvest as seen through the lens of Oregon's water quality standards. We designed the analysis to adhere as closely as possible to the Biologically Based Numeric Criteria (Numeric Criteria) and the Protecting Cold Water standard (PCW; see Oregon Administrative Rules 340-041-0028). The Numeric Criteria were assessed graphically with standardized temperature data. The PCW analysis required a more technical approach. We determined whether pairs of years demonstrated an exceedance of the standard at each of our 33 sites' upstream control, treatment, and (where available) downstream control reaches. We modeled temperature data for pairs of years using a Generalized Least Squares regression procedure. For each pair of years the earlier year served as the "baseline" against which the later year was compared. The procedure allowed us to assess background PCW exceedance rates and provided an exceedance history across the 33 sites to examine treatment (timber harvest) exceedance patterns. Results indicated that the Numeric Criteria were not generally threatened. However, the PCW analysis demonstrated an increase in exceedance rates when comparing pre-harvest years to post-harvest years on the treatment reaches of sites harvested to the minimum Forest Practices Act riparian buffer widths. Our analysis and its accompanying assumptions were strictly designed to address the language within the PCW standard. We therefore expect to better understand the magnitude and patterns of temperature change when we complete a different (and forthcoming) analysis.

Relating forest attributes with area-based and tree-based LiDAR metrics for western Oregon

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To assess the performance of area-level and tree-level LiDAR information as auxiliary forest data for Western Oregon, three sets of linear models were developed through subset regression techniques to predict several forest attributes using area-level and single tree remote sensing (STRS) LiDAR metrics as predictor variables. The first used only area-level metrics (ALM) associated with first return height distribution, cover percentages, and canopy transparency. The second included metrics of first return LiDAR intensity. The third used area-level variables derived from STRS LiDAR metrics. The ALM model for Lorey's height did not change with inclusion of intensity and yielded the best results in terms of both model fit (adjusted $R^2 = 0.93$) and cross-validated relative root mean squared error (RRMSE = 8.1%). The ALM model for density (stems/ha) had the poorest precision initially (RRMSE = 39.3%), but improved dramatically (RRMSE = 27.2%) when intensity metrics were included. The resulting RRMSE values of the ALM intensity exclusive models for basal area, quadratic mean diameter, cubic stem volume, and average crown width were 20.7%, 19.9%, 30.7%, and 17.1% respectively. Inclusion of intensity changed model precision for these attributes by no more than 3% in RRMSE. The STRS model for Lorey's height showed a 4% improvement in RRMSE over the ALM models. The STRS BA and density models significantly underperformed the ALM models with RRMSE values of 33.7% and 47.2%

respectively. The performance of STRS models for CW, volume, and QDBH were comparable to that of the ALM models.

How Can We Decide Which Small Stream Map is More Accurate? -Focusing on Sampling Method and Statistical Analysis

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The Washington State Department of Natural Resources' (DNR) Forest Practices Habitat Conservation Plan (FPHCP) requires establishment of riparian management zones (RMZs) or equipment limitation zones (ELZs). In order to establish RMZs and ELZs, the DNR is required to update GIS-based stream maps showing the locations of type Ns (Non-fish seasonal) streams as well as type S (Shorelines of the state), type F (Fish habitat), and type Np (Non-fish perennial) streams. While there are few disputes over the positional accuracy of large streams, the representation of small streams such as Ns and small type S or F streams (less than 10' width) have been considered to need more improvement of their positional accuracy.

Numerous remotely sensed stream-mapping methods have been developed in the last several decades that use an array of remote sensing data such as aerial photography, satellite optical imagery, and Digital Elevation Model (DEM) topographic data. While the positional accuracy of the final stream map products has been considered essential to determine the map quality, the estimation or comparison of the positional accuracy of small stream map products has not been well studied, and rarely attempted by remotely sensed stream map developers. Assessments of the positional accuracy of stream maps are not covered properly because it is not easy to acquire the field reference data, especially for small streams under the canopy located in remote forest areas. More importantly, as of this writing, we are not aware of any prominent method to estimate or compare the positional accuracy of stream maps. Since general positional accuracy assessment methods for remotely sensed map products are designed for at least two dimensional features, they are not suitable for linear features such as streams. Due to the difficulties inherent in stream features, estimation methods for stream maps' accuracy have not dealt with the positional accuracy itself but the hydrological statistics such as stream length or stream order. In this study, we suggest linear transactional sampling method and, practically, a stream and road crossing points - based sampling method to collect field stream position. We also review existing estimation methods and feasibility of the application of the error matrix, $\hat{K}$ and Z-statistics for stream maps, which have not been previously inspected. We find that the visual inspection, hydrological statistics, and headwater-based estimation methods provide insufficient information on the positional accuracy and that the error matrix and $\hat{K}$-statistics are effective in evaluating stream network positions by pairing a remote sensing data product with a field reference data, but Z-statistics still has limitation in comparing the two different remote sensing data products since the variance converges to zero.

3:15 – 5:00 Marine & Estuarine Surveys

A Stratified, Random Sampling Program to Examine Mercury in Small Fish from San Francisco Bay, California

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Tidal marsh restoration and other management actions have the potential to change mercury (Hg) concentrations in fish from the San Francisco Estuary, and elsewhere. Small forage fish are a useful biomonitoring tool to identify spatial variation in biotic methylmercury exposure in these areas. In particular, topsmelt and Mississippi silversides have previously exhibited statistically significant differences in Hg concentrations among multiple locations in the Estuary, and have a limited dispersal range, suggesting that they are appropriate indicators of spatial differences in Hg. During 2005 – 2007, the Regional Monitoring Program for Water Quality (RMP) performed a special study to evaluate Hg concentrations in small forage fish to assess spatial and inter-annual trends at nine fixed near-shore stations and 26 other locations distributed throughout San Francisco Bay. Based on three years of data, the initial study findings supported a conceptual model that distinguished open water Bay fish from those that reside in wetlands and Bay margins. The conceptual model represents a set of working hypotheses to be tested and modified with further study. Therefore, the RMP initiated a new study design in 2008 to explicitly test the spatial hypotheses. The study employed the Generalized Random-Tessellation Stratified design software developed by Don Stevens (OSU) and Tony Olsen (USEPA). The study design included strata for potential Hg source areas, including wetlands, industrial sites, and waste-water treatment plants. The study also included a separate stratum focused on locations probabilistically selected from among the entire Bay shoreline. The design will also help assess where the greatest hotspots for Hg entering the food-web may exist in the Bay. Results from the 2008 sampling season indicate a broad spatial gradient with elevated Hg in proximity to the Guadalupe Watershed, a location with legacy Hg mining. Contrary to initial expectations, results suggest Hg to be lower near waste-water treatment plants, suggesting that Hg biodilution may occur in these locations.

Two-phase survey design for mapping oceanic sediment condition surrounding two treated wastewater outfalls in San Diego.

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Maps are useful tools for understanding, managing and protecting our marine environment. Despite the benefits, there has been little success in developing useful and statistically defensible maps of environmental quality and aquatic resources in the near coastal regions. Treated sewage outfalls, for example, typically rely on relatively sparse monitoring grids (< 30 sites) to assess the effect of their effluent on the oceanic sediment and sediment-dwelling organisms. Heterogeneous oceanic conditions often make extrapolation of data collected from these grid sites to non-sampled locations questionable. Kriging is a statistical approach that uses information observed at sampled locations to improve predictions at non-sampled locations. The precision and accuracy of those predictions rely entirely on our ability to capture the spatial variability or what is referred to as the variogram. In addition, the variogram can be used to determine the optimal sample spacing for future monitoring. In this study we rely on a simple two-phased sampling approach for creating maps of oceanic sediment quality surrounding two sewage-treated outfalls in San Diego. In phase I (2004), we applied a multi-lag cluster grid enhancement to existing monitoring grids to estimate the variograms for a host of chemical and benthic indices. We use this information to explore different strategies for modifying their existing grid for creating maps with statistical confidence in phase II (20010). In this presentation, we will highlight some of the challenges associated with creating maps of ocean conditions in near coastal environments.

Spatial modelling of prawn abundance from large-scale marine surveys using penalised regression splines

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Since the 1970s, CSIRO has been closely involved in assessing the status of prawn stocks in the Northern Prawn Fishery (NPF), fitting population dynamics models to commercial catch data and conducting prawn ecology research. Between 1975 and 1992, there were three key series of monthly surveys of limited regions. However, there was no ongoing monitoring of multiple regions due to the high cost of conducting such surveys and the apparent wealth of data from commercial logbooks. An international review of the management process for the NPF in 2001 recommended that annual multi-species fishery-independent surveys be introduced to augment the population dynamics models and monitor the health of the fishery. Bi-annual surveys of prawn distribution and abundance have now been undertaken for the past seven years, at 300 sites for each recruitment survey and 200 sites for each spawning stock survey. The locations were randomly selected from areas of frequent fishing activity.

An MCMC approach to fitting P-splines implemented in BayesX (http://www.stat.uni-muenchen.de/~bayesx) was used for spatial modelling of the density of several commercial prawn species. Some adaptation was needed to enable simultaneous modelling of a number of discrete survey areas distributed throughout the 300,000 km² Gulf of Carpentaria. The Bayesian approach leads very straightforwardly to mean density estimates for each survey area as well as the entire region, with associated credible intervals. This computationally intensive approach is compared with more routine design-based estimates and bootstrap confidence intervals.

Sampling Headwater Streams for Autocovariance Parameter Estimation

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Attention to patterns of spatial autocovariance in ecology has shifted dramatically. Initially, the use of geostatistical methods allowed scientists to account for spatial autocorrelation in their data to estimate linear model parameters and to make predictions at unobserved locations. More recently, ecologists have begun to focus attention on the spatial process itself, recognizing the implications of variance patterns across their systems of study as valuable descriptive tools, rather than simply sources of non-independence in their data. To describe and compare the spatial patterns of ecological phenomenon requires spatially explicit data which are obtained through sampling. Inferences for spatial data are affected substantially by the configuration of the network of sites where measurements are taken and efficient autocovariance parameter estimation if significantly affected by the sampling design. There exists a solid and consistent body of work on the estimation of spatial autocovariance parameters for geostatistical data collected in planer landscapes which suggest that the best sampling designs contain tight clusters of sampling locations which are spread throughout the sampling domain. These results may not be sufficient for stream ecologists. Stream systems are confined by their network structure and spatial autocovariance may be influenced by water flow and described best by distances separating sampling units via the network structure. We compare the spatial autocovariance parameter estimation performance of four sampling schemes using coastal cutthroat trout data obtained from 40 randomly chosen headwater basins in Western Oregon. Spatially balanced probability samples generated using the Generalized Random Tessellation Stratified (GRTS) methodology, samples generated using simple random sampling, cluster samples obtained using GRTS to select cluster center locations, and cluster samples obtained by placing all sampling clusters at tributary confluence locations are considered.

Wednesday, June 17

8:00 – 9:45 Models for Environmental Data

Multispecies Occupancy Models for the Analysis of Metacommunity Dynamics

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The metacommunity concept occupies a prominent role in ecology and provides a conceptual framework for describing processes involved in the formation and evolution of species assemblages. Theoretical ecologists have developed a variety of metacommunity paradigms, including models of "patch dynamics", "neutrality", "species-sorting", "mass effects", and a growing list of other mechanisms assumed to underlie the dynamics of metacommunities. Interestingly, metacommunity theories (and their associated jargon) continue to be advanced without much empirical validation, except for a few "tests" of neutral models.
Here, we describe and illustrate a statistical modeling framework for the analysis of metacommunity dynamics. This framework is based on the idea of adopting a unified approach - multispecies occupancy modeling - for computing inferences about individual species, about local communities of species, or about an entire metacommunity of species. We identify the sampling requirements needed to apply this approach, and we illustrate their benefits in an analysis of phenologies of butterfly species in Switzerland. In this analysis we formulate models to estimate the effects of habitat characteristics, dispersal, and interactions among species on seasonal changes in composition of species in butterfly communities.

Towards an integrated structural model for Oregon Coastal coho.

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Standard regression models do find some associations between the variables in the juvenile, spawner and habitat, however, they are not capable of incorporating the real structure of these data. For example, the data are all measured with considerable error, whereas regression models assume the explanatory variable is measured without error. It is also the case that many other sources of relevant data are available, such as data from hatchery tagging studies, fishery catch rates, index sites, and fish-passage counts. A more flexible approach is required to make best use of all available data data, and to model the inherent temporal structure in these data. An integrated structural model is proposed. This approach gains its strength from the property that several different sources of data may each provide information about a common underlying quantity of interest.

Predictive modeling and mapping sage grouse (Centrocercus urophasianus) nesting habitat using Maximum Entropy and a long-term dataset from Southern Oregon

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Predictive modeling and mapping based on the quantitative relationships between a species and the biophysical features (predictor variables) of the ecosystem in which it occurs can provide fundamental information for developing sustainable resource management policies for species and ecosystems. To create management strategies with the goal of sustaining a species such as sage grouse (Centrocercus urophasianus), whose distribution throughout North America has declined by approximately 50%, land management agencies need to know what attributes of the range they now inhabit will keep populations sustainable and which attributes attract disproportionate levels of use within a home range. The objectives of this study were to 1) quantify the relationships between sage grouse nest-site locations and a set of associated Biophysical attributes using Maximum Entropy, 2) find the best subset of predictor variables that explain the data adequately, 3) create quantitative sage grouse distribution maps representing the relative likelihood of nest-site habitat based on those relationships, and 3) evaluate the implications of the results for future management of sage grouse. Nest-site location data from 1995 to 2003were collected as part of a long-term research program on sage grouse reproductive ecology at Hart Mountain National Antelope Refuge. Two types of models were created: 1) with a set of predictor variables derived from digital elevation models, a field-validated vegetation classification, and UTM coordinates and 2) with the same predictors and UTM coordinates excluded. East UTM emerged as the most important predictor variable in the first type of model followed by the vegetation classification which was the most important predictor in the second type of model. The average training gain from ten modeling runs using all presence records and randomized background points was used to select the best subset of predictors. A predictive map of sage grouse nest-site habitat created from the application of the model to the study area showed strong overlap between model predictions and nest-site locations.

Estimating aquatic vegetation occurrence and abundance using the rake sampling method

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The rake measurement method is used to monitor the distribution and abundance of aquatic vegetation in lakes, rivers and estuaries. In particular, the method has been proposed by the Great River Ecosystem section of the USEPA's Environmental Monitoring and Assessment Program for use by States for regulatory purposes. The method consists of passing a long-handled double-sided garden rake over aquatic substrates. The volume of captured plant material is then scored using a 6-category system, with increasing score assignment reflecting increasing volume on the rake. Unfortunately, classification errors associated with the rake method ensure that occurrence probabilities and abundance indices derived from rake data will underestimate truth, with underestimation not proportionally constant across species, substrate or sampling depth. Where sampling designs incorporate multiple rake surveys per sampling site, occurrence probabilities and abundance may be estimated with correction for classification errors using site occupancy and multinomial mixture models, respectively. Unfortunately, such models will yield biased estimates under settings commonly seen with rake data, including when correct classification probabilities are not only low but also vary substantially among sampling sites. A further complication associated with the use of these models with rake data is that aquatic vegetation presence and abundance are often heterogeneous within sampling sites. We explore the use of empirical Bayes and Markov chain Monte Carlo (MCMC) models of occupancy and multinomial mixture models that allow for

heterogeneous classification probabilities. Preliminary results suggest that MCMC heterogeneity models will yield estimates with relatively minor bias (e.g., < |10%|) when sites $\geq$ 40, surveys per site $\geq$ 6, classification probabilities are not small and heterogeneity is modest. The implications of these findings are discussed within the context of the development of aquatic vegetation monitoring programs.

10:15 – 12:00 Landscapes and Coho Salmon

Introduction to the Oregon Story: Linking landscapes to coastal coho and habitat.

D.P. Larsen, E.A. Steel, K.J. Anlauf , J.C. Firman, D.W. Jensen, K.M. Burnett, K. Christiansen, and B.E. Feist

Introduction to the session on Landscapes and Coho Salmon

How broad the horizon? Landscape models of adult coho salmon density examined at four spatial extents.

Julie C. Firman, E. Ashley Steel, David W. Jensen, Kelly M. Burnett, Kelly Christiansen Blake E. Feist, David P. Larsen and Kara Anlauf

There is a growing body of literature examining relationships between landscape characteristics and the distribution and abundance of populations of organisms. The spatial extent at which these relationships are examined can have important consequences on model results. Efforts to identify the best or most appropriate spatial scale for modeling suggest that a multi-scale approach is important to determine the extent over which, and mechanisms by which, landscape conditions affect in-stream conditions. We modeled the spatial distribution of the density of spawning coho salmon (*Oncorhynchus kisutch*) as a function of landscape characteristics such as geology, road density, climate, vegetative cover, and land use. We used geospatial data to quantify landscape characteristics at four spatial extents (100 m streamside buffer, 500 m streamside buffer, all adjacent hydrologic units: mean area =18 km^2, and the catchment upstream of the reach: mean area =17 km^2). All models were fit with maximum likelihood procedures and AIC were used to select the best models after removing models with various forms of model instability. Field datasets are rarely available that reflect such a favorable combination of qualities for model building, i.e. a large number of sites (N = 44), evenly distributed throughout a large area (20,305 km2), with a long and consistent history of data collection (17 of 50 years of data were used for this study). In addition, comprehensive, high-resolution landscape data enabled predictions of relative fish densities with a high degree of precision. Predictions from models incorporating land use, land ownership, geology and climate variables were significantly correlated (r = 0.66 to 0.75) with observed adult coho salmon in the study area. In general, coho densities (peak count of adults/km) were greatest in undeveloped forest land with less area in weak rock types, lower densities of cattle and roads, and in areas with a greater range in maximum and minimum winter temperatures. Because salmon occupy large areas over which detailed habitat surveys are not feasible, the ability to predict the spatial distribution of coho salmon spawners from landscape data has great utility in guiding conservation and restoration efforts.

Comparing riverine landscape models across populations and sampling designs to understand spawning distributions of coho salmon (*Oncorhynchus kisutch*)

E.A. Steel[1], D.W. Jensen[1,2], K.M. Burnett[3], K. Christiansen[3], J.C. Firman[4], B.E. Feist[1], K.J. Anlauf[4], and D.P. Larsen[5]

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Species distribution and abundance of fishes and aquatic species are often correlated with landscape-scale patterns of geology, climate, and land-form as well as human disturbance. Understanding and monitoring these relationships is essential to effective conservation of declining populations. Correlations between landscape condition and species distribution are often based on observations from non-random, long-term monitoring programs Coho salmon (Oncorhynchus kisutch) populations are declining rapidly and data from a large number of randomly selected monitoring sites is only recently available. We apply a series of spatial and statistical analyses to spawner surveys of coho salmon in this new dataset in order to (1) compare data structure and model performance between found data sets collected to monitor specific populations and our dataset built from randomly selected survey sites; and (2) build a model of coho salmon spawning behavior that accounts for both occupancy and abundance. We applied variance-partitioning methods to this dataset and to previously published datasets to compare data structure. To compare model performance, we applied a set of statistical analyses to this dataset that parallel previously published analyses. We also identified a better approach for this new data set. Because of the large number of zeros, the best model for this dataset was a hurdle model based on (1) a logistic regression for presence/absence of spawners and (2) a mixed linear model of abundance where fish were present. Comparing data structure across all available datasets, we found that most of the variation in spawner abundances occurs between sites but much also occurs between years and that similar but not identical suites of landscape predictors are correlated with coho distribution. For our dataset, we determined that landscape conditions could not explain presence/absence of spawners but that the percent of agriculture and the intrinsic potential of the stream could explain a reasonable proportion of the variation in abundance (weighted average r2 = 0.30) where spawners are present. We conclude that while landscape conditions clearly impact coho abundance, they are not correlated with occupancy; this distinction may have particular importance for the management of declining species.

A mechanistic approach to explain the variation in coho salmon (*Oncorhynchus kisutch*) habitat across the landscape

K.J. Anlauf , D.W. Jensen, E.A. Steel, K.M. Burnett, K. Christiansen, J.C. Firman, B.E. Feist, and D.P. Larsen

In this study, we describe the spatial patterns of twelve instream habitat features as a function of landscape composition. We focus on the mechanistic relationships that drive the presence and complexity of particular aquatic habitats. In an attempt to disentangle anthropogenic landscape effects, we separated and summarized landscape factors within watersheds into three groups: 1) stream power indicators, 2) immutable or un-managed factors, and 3) management influenced factors. Instream habitat was surveyed across the Oregon coast at sites selected from a probabilistic, spatially balanced sampling design. Stream habitat features were chosen based on their sensitivity to management, importance to fish, and their

implicit relationship to the landscape. We partitioned the variability present in the dataset, comparing the amount of site-to-site variation to the amount of year-to-year variation using a random effects model. We then followed a three step process by first regressing geomorphic landscape habitat factors characteristic of stream power, as these often pre-determine instream habitat potential. Second, we added immutable or un-managed factors to the best models identified in the first step. Finally, we added management influenced factors to the best models identified in the second step. We added one and two variable combinations of immutable and management influenced covariates subsequently and used several criteria to determine inclusion in the set of candidate models. Final models were composed of the landscape factors from each group that best described the spatial variation seen in stream habitat. To assess prediction proficiency, we applied the suite of models identified in the analysis to the appropriate landscape factors at 95 random sites, using the root mean squared prediction error (RMSPE) and the correlation between the observed versus predicted responses as indicators of precision. Stream habitat features and complexity were influenced and driven disproportionately by diverse landscape factors in each grouping. Our results highlight the importance of assessing spatial patterns in instream habitat from a landscape perspective in order to reveal more pertinent details about finer scale complexity. By segregating management influenced factors from more immutable or natural gradients, we are able to identify those habitat variables more sensitive to land use pressures.

1:00 – 2:15 Monitoring Oregon's Water Quality

Oregon's Water Quality Monitoring Strategy.

Aaron Borisenko
Oregon Department of Environmental Quality, Laboratory and Environmental Assessment Division, 3150 NW 229th Avenue, Suite 150, Hillsboro, Oregon 97124.

Oregon DEQ's Monitoring strategy was developed in 2005 to address a variety of data needs. Available resources make implementation of the strategy challenging but the plan provides the framework to assess important questions about the status and trends of Oregon's waters, the effectiveness of our management practices, the discovery of emerging pollution issues and compliance with pollution laws. The plan outlines a rotating basin geographic approach which utilizes both probabilistic and targeted sampling to answer questions at different spatial and temporal scales. Indicators outlined in the strategy include conventional water quality parameters, toxics, biological indicators and physical habitat measurement. In addition, the plan includes water bodies like lakes, reservoirs and wetlands that are not currently being actively monitored at this time. Taken together, the strategy provides the foundation for collecting data to answer the important questions facing Oregon's water quality and watershed health now and in the future.

High Level Indicators of the Water Resources of Oregon's Forested Streams.

Shannon Hubler, Sarah Miller, Leslie Merrick, Robin Leferink, and Aaron Borisenko.
Oregon Department of Environmental Quality, Laboratory and Environmental Assessment Division, 3150 NW 229th Avenue, Suite 150, Hillsboro, Oregon 97124.

Maintaining and improving the condition of water resources on Oregon's forest lands is one of the objectives adopted by the Oregon Board of Forestry to mark Oregon's progress towards sustainable forest management. The Oregon Department of Environmental Quality has completed an assessment of the water quality and aquatic macroinvertebrate status of streams in Oregon's forested lands at the request of the Oregon Department of Forestry. Most samples used in this assessment were collected in probabilistic monitoring programs conducted by DEQ, other agencies, universities and volunteer monitoring groups.

Conditions are reported for all forested lands in the state, by major basin, and by land ownership class. Although the overall water quality of the state's forested streams is in excellent condition, the aquatic macroinvertebrates indicated that approximately one quarter of the sites showed disturbed conditions compared to least human impaired reference conditions.

An Innovative Approach to Regional Monitoring and Assessment: The Willamette Basin Rivers and Streams Assessment

Michael Mulvey, Robin Leferink, and Aaron Borisenko
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Oregon's Willamette basin is the hub of the state's population and economy with 70% of the state's population, 75% of the state's employment, and 12% of the state's land area. The basin contains some of the state's most challenging water quality issues. In recent years more than a dozen stream and river surveys have monitored approximately 650 sites on streams and rivers in the Willamette basin using US EPA's Generalized Random Sampling Design (GRTS) and Environmental Monitoring and Assessment Program (EMAP) protocols. Monitoring was conducted by municipal, state and federal governments; university researchers, and local watershed councils. The Oregon Department of Environmental Quality has amalgamated these various compatible data sets to evaluate stream and river status for the entire basin, for land use types and for 12 sub basins using a range of biological, water quality and physical habitat condition indicators. Randomly selected sites are compared with least human impaired reference sites to evaluate the role of natural conditions and human activity to the current stream and river status.

2:45– 4:30 Rotating Panel Surveys for Status and Trend

Stratified Rotating Panel Survey With Regression Imputation: A Sampling Strategy for Estimating Total Number of Bald Eagle Nesting Territories in Florida

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The bald eagle is an important species for conservation and so accurate estimation of its true abundance is important for development of adequate conservation strategies. The state of Florida has traditionally performed annual aerial censuses of every county in the state with the intent of obtaining an estimate of the yearly total number of nesting territories. Several benchmarks for maintenance and growth of the population are part of the overall state management plan. Some of those involve estimating various categories of nests include active, abandoned, reproducing, and similar. As a result, the sampling strategy must be modified to allow repeat visits to sampled sites in order to obtain more detailed information than can be obtained in a single visit. We address in this talk the question of precise estimation of the total abundance of nesting territories using panel surveys to replace the census. The sampling design is a three year rotation design in which panels of contiguous counties within the state of Florida are assigned to a particular year of the three year rotation. The estimation procedure is model-based and relies on imputing the number of nesting territories that would have been observed in a county had it been in the sample rotation that year. The imputation is based on Poisson regression of previously collected counts assuming linearity and county-specific slopes. Counties vary greatly in the number of nesting territories and in the change in numbers over time with some counties showing no change over time and others having increasing numbers of nesting territories being created each year. The results are then used in estimation of the total number of nesting territories in the state. We consider several approaches to fitting the regression models, including maximum likelihood estimation of the parameters, least squares estimation

(LSE), a modified LSE where standard errors of the predicted values are estimated by replacing MSE in the standard formula with the predicted value from the regression, and simple forward imputation of the last observed value. The approaches are compared using data collected in censuses of all counties annually from 1990 to 2000. Overall, the LSE with modified standard errors behaved the best in terms of accurately reflecting the census results. Future work includes an explicit spatial approach using neighboring counties to fine-tune the imputation procedure.

Trend Analysis in the Context of Design Based Sampling of Spatially Distributed Resources

Bill Gaeuman
Department of Statistics, Oregon State University

Numerous state and federal agencies and other entities are charged with monitoring spatially distributed resources for "status and trend." Common examples of such resources include animal populations, stream networks and forest regions. Often, however, what is meant by trend is unspecified or described only vaguely. I examine different ways of characterizing trend in this setting and present a framework for its analysis based on a probability sample. I argue that careful thinking about these issues is necessary for ensuring that the analysis appropriately addresses management objectives and concerns. I illustrate some of these ideas using data collected under the Aquatic and Riparian Effectiveness Monitoring Program (AREMP).

Calculating the power to estimate trend with a linear mixed model for unbalanced data from a panel design

Leigh Ann Harrod Starcevich[1], Andrea M. Heard[2,4], Kathryn M. Irvine[3], and Linda S. Mutch[4]
1: Oregon State University; 2: University of California, Riverside; 3: Montana State University; 4: National Park Service, Sierra Nevada Network Inventory and Monitoring Program.

Trend estimation is a primary goal for many long-term natural resource monitoring programs. The linear mixed model is a useful tool for estimating the magnitude of trend while accounting for sources of variation encountered in ecological data. When data are collected in a panel design resulting in unbalanced data, the effect on the power to detect trend depends on the estimation method and degrees of freedom approximation used. Publications on trend and power to detect trend address different trend hypothesis tests and propose different models for trend estimation. We discuss the impacts of choices regarding revisit designs, trend hypotheses, models, degrees of freedom, and estimation methods.

Using Imputation to Estimate Trend and Abundance in Coho Salmon Numbers using a Multi-Period Rotating Panel Sampling Design

Don L Stevens, Jr.
Department of Statistics, Oregon State University

The Oregon Department of Fish and Wildlife implemented a spatially balanced rotating panel sampling design for Oregon coastal coho salmon in 1998. The panel structure of the design is tied to the 3-year life cycle of coho salmon, with a panel visited every year, 3 panels visited on a 3-year repeat cycle, 9 panels visited on 9-year repeat cycle, and 27 panels visited on a 27-year cycle. Each year, the annual panel, and one panel from each rotation are visited, for a total of four panels per year. In this talk, I'll discuss the rationale for the design, and some advantages of spatially balanced rotating panel designs in general. I'll

also show how the rotating panel design can be used to increase the effective sample size for status estimation and trend detection and description. The techniques are illustrated using the coastal coho data.