

Work Package 6: EO-based Ecosystem Modelling: Update Summary

Mountain ecosystems

Gran Paradiso National Park (M1/M4) (Partners: CNR, EPFL, UFZ)

Assessing population trends. According to the unstructured population model, population of chamois appears to remain stable or slightly increase under scenarios RCP4.5 and RCP8.5 in the period 2013-2100. Projections based on structured population models, however, predicted a slight decrease of the population in the same period.

Both grey heron (*Ardea cinerea*) and little egret (*Egretta garzetta*) populations increased till 2000 but then began to decrease, mainly in the region of intensive rice cultivation, where the trend was likely driven by reduced flooding of the paddies due to a change in rice cultivation methods.

Assessing the impact of landscape topography on species distribution. Models developed showed that the fate of specialist species is highly conditioned by the local landscape features, which might not allow them to track future changes in temperature. EPFL is now calibrating the model with respect to data of carabids species collected at the GPNP.

Temporal transferability of remote-sensing based species distribution models. Ensemble models for Staphylinidae distributions (*Dinothenarus fossor*, *Platydracus stercorarius*, and *Ocypus ophthalmicus*) using Landsat 5 and 8 data were implemented in R for the years 2006 and 2013. Results showed distinctive patterns regarding variable importance for each species (e.g., selection of Tasseled Cap greenness over Land Surface Temperature) while variable importance differed between the two study periods (very likely due to different extents of snow and cloud cover).

Lakes Ohrid and Prespa (M5) (Partner: UP)

Assessing climate change vulnerability tailored to freshwater ecosystems. A novel framework was developed showing that the Balkan Lakes Ohrid and Prespa and Mediterranean islands emerge as most vulnerable to climate change. A gap analysis demonstrated that the current European protected area network covers less than 25 % of the most vulnerable catchments.

Modelling chlorophyll-a concentrations in Lakes: Water Quality Drivers, Recent Changes, Status and Trends across European Perialpine and Balkan Mountain Lakes. Chlorophyll-a (Chl-a) modelling was conducted using linear and non-linear statistical modelling approaches: Panel Data Models (PDMs), Generalized Additive Models (GAMs) and Boosted Regression Trees (BRTs). Besides in situ measurements of the nutrients and lake morphometric parameters, Chl-a models include lake surface water temperature (LSWT) in situ measurements supplemented by remote sensing based LSWT data. Based on the combination of in situ and remote sensing data we assessed changes in the land cover and trophic status, LSWT trends and threatened species statistics across lakes from mountain regions.

Northern Limestone Alps (M2) (Partner: KIT and EAA)

Simulation of Carbon sequestration. We investigated a 15-year time period from 2000 - 2015 including the storm events Kyrill, Paula and Emma, which hit Europe in the years 2007 and 2008. Ecosystem carbon fluxes were reconstructed with the process-based ecosystem model LandscapeDNDC, which was initialized, calibrated and validated with extensive field and remote sensing monitoring data. We found that the fast development of grasses and herbs after stand-replacing disturbances significantly contributes to the overall reduction of carbon loss from this forest landscape. Climate change will likely increase ecosystem N retention in temperate forest ecosystems, and even more so at forest sites with high past N deposition. While plot-based measurements showed that it reduces carbon loss by approximately 50% after disturbance, model based scenario analysis detailed the effects of failed versus vital tree regeneration in disturbed areas with and without an herb and grass layer at the landscape scale.

Peneda-Gerês National Park (Partner: ICETA)

Habitat suitability model implementation in R: models exhibited very good performance regarding AUC ($AUC_{median} > 0.88$) and TSS median metrics ($TSS_{median} > 0.6$), supporting the use of satellite-derived Ecosystem Functional Attributes (EFAs) as meaningful EBVs in species distribution models at multiple scales.

Hydrological impacts of fires under future climate scenarios. MODIS LAI is improving interactive parameterization of leaf area index of major vegetation types. MODIS NDVI is been used to input information on SWAT vegetation post-fire regeneration management operations.

Temporal transferability of bird species distribution models. Correlative models implementation in R for 27 bird species. The combination of climate, land cover and EFAs substantially increased SDM performance but temporal transferability was usually low ($AUC > 0.7$ for less than 25% of species).

Assessing grassland conservation targets in protected areas. Modeling framework implementation combining predictions from a grassland detection model and from a plant species richness model, to measure grassland conservation targets revealed a substantial and significant reduction of habitat coverage after the authoritarian period in Portugal and until the adhesion of the country to the Euro zone, but also a reduction on the magnitude of habitat loss and even a slight recovery after Portugal has joined the European Union.

Sierra Nevada (M8/M9) (UGR)

Snow cover maps and hydrological modelling. The snow maps generated by EURAC for the whole Sierra Nevada for the period 2002-2016 are used for calibration of the snowmelt routine of the WiMMed hydrological model using the internal procedures of the model. The model has been run for different land use scenarios (1956, 1977, 1984, 1999, 2003 and 2007) and some resulting variables have been taken as indicators for the ecosystem services of erosion, water provisioning and flood control.

Estimation of fragmentation index of landscape heterogeneity for the aesthetic value as a cultural ecosystem service indicator. CERTH provided a set of fragmentation indexes of landscape based on a land cover series (years 1956, 1977, 1984, 1999, 2003 and 2007). We used this dataset to calculate the aesthetic value as a cultural ecosystem service indicator for those years. The aesthetic value was analyzed at two different scales: watershed and the MODIS resolution. Now we are assessing trade offs between this cultural ecosystem service and other provisioning and regulating ecosystem services.

Coastal and marine ecosystems

Doñana (Partner: EBD-CSIC)

Development of predictive maps of annual biomass production from 2000 to 2016 at 250 m resolution using statistical models. The models have made use of in-situ data (collected regularly by other research projects at Doñana PA) and MODIS NDVI used as predictor. The distribution of environmental changes appears uneven and hugely varies from the local to the regional scales. Available industrial fishery data suggest a worrying coincidence whereby the world's richest areas for marine biodiversity are also those areas being impacted most from both climate change and industrial fishing.

Development of a horizon-scanning framework and identification of emerging issues on waterbird conservation.

Species distribution models, boosted regression tree and generalized additive models were used to find that waterbird species appeared unevenly distributed throughout environmental gradients with water salinity being the most important gradient structuring the distribution of the community. Environmental suitability for the guilds of diving birds and vegetation gleaners will be reduced in future climate scenarios, while many small wading birds will benefit from changing conditions. Resident species and those that breed in this wetland network will be also more negatively impacted than those using this area for wintering or stopover.

Camargue (O5) (Partner: UNIVLEEDS)

Assessing patterns in recreation use through social media. Machine learning was used for content analysis of geotagged photos from Flickr, before the resultant image descriptors were used in Latent Semantic Analysis to cluster user types. Protected Area managers can harness social-media to monitor recreation and improve their management decision making using machine learning and natural language processing to collect and interpret photos posted on social-media.

Pelagos (O6) (UBO)

Production of habitat trend maps. Feeding habitat of fin whales was mapped over the period of 2003-2016 and maps revealed a spatially heterogeneous trend in Chlorophyll a fronts in the Mediterranean sea.

Wadden Sea (O1) (Partner: DELTARES)

Improvement of forecasting for primary and benthic production with remote sensing. The integration of photosynthetically active radiation (PAR), Chlorophyll a, and suspended particulate matter into the model has led to improved hindcasting capabilities and allow allowed for corrections within the model state space in order to have a more accurate departure point for future forecasts. Such hindcasting correction should allow for improved future states based on nutrient uptake and sequestration.

Mediterranean sea (Partner: FORTH)

Assessing species invasion patterns. Distribution modelling was used to find that lion fish will reach Gibraltar no later than 2050: super invader with high plasticity, adapted to new environments when dispersal barriers are overcome.

Models for evaluating ecological connectivity in the LME (Partner: POLIMI)

Connectivity is a basic yet key ecosystem service in marine landscapes. Using oceanic re-analyses incorporating remote sensed measurements as drivers for lagrangian biophysical modelling of *Posidonia oceanica*, we contrasted the potential connectivity emerging from simulations with genetic sampling in some populations of the Adriatic-Ionian seas. Also, at the scale of the whole LME, we evaluated spatiotemporal patterns of potential connectivity for *Posidonia oceanica* over a climatic relevant temporal frame (1987-2015). Although some components of connectivity tend to be quite erratic, there are geographical scales where statistically significant trends are detected.

Arid/semi-arid ecosystems

Har Hanegev (A1) (Partners: BGU, UP)

Assessing the resilience of terraced dry riverbeds. Mathematical analytical model revealed a sharp decline in functional diversity and total biomass as the number of rainfall events increases and their intensities decrease. Change

in tradeoff calibration (convex to concave) resulted in an increase of functional diversity and a decrease in total biomass.

Assessing climate impact on vegetation cover. The means for all realisations and all climate models clearly indicate a decline in vegetation cover with a decrease of 50 % and 60 % for RCP4.5 and RCP8.5, respectively, resulting in, respectively a coverage of 12% and 8% by 2100. Simulations predicted a shift in plant distribution (due to a significant decrease in perennials and shrubs in both RCP scenarios while the annuals are declining only moderately) and suggested an underestimation of vegetation-relevant input parameters in the downscaled data (compared to measured data within the area).

Samaria National Park (Partner: FORTH)

Suitability maps for the Cretan Lizard was developed using species modelling with hyper temporal Sentinel 2 data to help conservation activities.

Publications

Published

Northern Limestone Alps (M2) (Partner: KIT and EAA)

1. Dirnböck T., Foldal C., Djukic I., Kobler J., Haas E., Kiese R., Kitzler B. (2017). Historic nitrogen deposition determines future climate change effects on nitrogen retention in temperate forests. Climatic Change. DOI 10.1007/s10584-017-2024-y.

Gran Paradiso National Park (M1/M4) (Partner: EPFL)

2. Bertuzzo, Enrico, et al. "Geomorphic controls on elevational gradients of species richness." Proceedings of the National Academy of Sciences 113.7 (2016): 1737-1742.

Doñana (Partner: EBD-CSIC)

3. Lumbierres M, Méndez PF, Bustamante J, Soriguer R, Santamaría L. Modeling Biomass Production in Seasonal Wetlands Using MODIS NDVI Land Surface Phenology. Remote Sensing. 2017;9: 392. doi:10.3390/rs9040392
4. Ramírez, Francisco, et al. "Climate impacts on global hot spots of marine biodiversity." Science Advances 3.2 (2017): e1601198.

Murgia Alta (A3) (Partner: CNR)

5. D. Lacitignola, F. Diele, C. Marangi, A. Provenzale, On the dynamics of a generalized predator–prey system with Z-type control, Mathematical Biosciences, 10.1016/j.mbs.2016.07.011
6. F. Diele, C. Marangi, "Positive simplectic integrators for predator-prey dynamics", Discrete and Continuous Dynamical Systems - Series B, online version already available since July 2017, doi:10.3934/dcdsb.2017185.

Lakes Orhid and Prespa (M5) (Partner: UP)

7. Markovic, D., Carrizo, S.F., Kärcher, O., Walz, A. and David, J.N., 2017. Vulnerability of European freshwater catchments to climate change. *Global Change Biology*.

Mediterranean Sea (Partner: Polimi)

8. Jahnke M., Casagrandi R., Melià P., Schiavina M., Schultz S. T., Zane L., Procaccini G. Potential and realized connectivity of the seagrass *Posidonia oceanica* and their implication for conservation. Diversity and Distributions, 23(12), pp. 1423-1434., 2017. doi:10.1111/ddi.12633

In review/ submitted

Murgia Alta (A3) (Partner: CNR)

1. C. Baker, F. Diele, D. Lacitignola, C. Marangi, A. Martiradonna, Hypersensitive optimal control of invasive species through dynamical systems approach, submitted to Discrete and Continuous Dynamical Systems - B, under revision
2. Martiradonna, F. Diele, C. Marangi, Analysis of state-control optimality system for invasive species management, submitted to Proceedings of ISAAC 2017, Springer/Birkhäuser series "Trends in Mathematics, Research Perspectives".

Northern Limestone Alps (M2) (Partner: KIT and EAA)

3. Dirnböck, T., Kraus, D., Kobler, J., Thom, D., Seidl, R., Haas, E., Kiese, R. Post-disturbance ground vegetation effects on carbon sequestration in a temperate forest landscape. European Geosciences Union General Assembly 2018.

Peneda-Gerês National Park (Partner: ICETA)

4. Arenas-Castro S, Gonçalves J, Alves P, Alcaraz-Segura D, Honrado JP. Assessing the multi-scale predictive ability of ecosystem functional attributes for species distribution modelling. [PLOS ONE. Under review from the last November 15 2017]

5. Regos, A., Gagne, L., Alcaraz-Segura, D., Honrado, J. Dominguez, J. Effects of species traits and environmental predictors on performance and transferability of distribution model.[Journal of Biogeography, under review from January 2018].

Samaria National Park (Partner: FORTH)

6. Poursanidis, D., Kalogirou, S., Azzurro, E., Parravicini, V., zu Dohna, H., Bariche, M. 2018. Distribution modelling and spread of the invasive lionfish in the Mediterranean Sea. Scientific Reports.

Gran Paradiso National Park (M1/M4) (Partner: CNR,EPFL)

7. Imperio S., Corlatti L., Bassano B., Provenzale A. Population dynamics of a mountain ungulate between past and future uncertainties. Global Change Biology.

8. Giezendanner, J., Bertuzzo, E., Pasetto, D., Guisan, A., Rinaldo, A. "Geomorphic effects on metapopulation range dynamics and extinctions under climate change". To be submitted to PNAS.

Montado (A4) (Partner: IST)

9. Simionesei, L., Ramos, T., Jongen, M., Weber, K., Proença, V., Domingos, T., Neves, R. Modeling soil water dynamics and pasture growth in the agro-silvo-pastoral ecosystem using a process-based model and remote sensing data [Under review].

Doñana (Partner: EBD-CSIC)

10. Ramírez, Francisco, et al. "Environmental drivers of habitat associations for the waterbird assemblage of south-west Spain: A horizon-scanning perspective" and Lumbierres, et al. "Modeling biomass production in seasonal wetlands using MODIS NDVI Land Surface Phenology" in Remote sensing.

Pelagos (O6) (UBO)

11. Madon, B, Garelló, R, David, R, Fablet, R, Pendleton, L. 2017. Strike-Alert: Towards Real-Time, High Resolution Navigational Software for Whale Avoidance. In Review for the SusTech Conference.

In preparation

Camargue (O5) (Partner: UNIVLEEDS)

1. Gosal, A., Ziv, G., et al. Assessing recreational visitor groups using Flickr, machine learning and natural language processing [to be submitted approx. March 2018]

Northern Limestone Alps (M2) (Partner: KIT and EAA)

2. Dirnböck, T., Kraus, D., Kiese, R., Kobler, J., Grothe, R. Seidl, R., Thom, D. Post-disturbance ground vegetation effect on carbon sequestration in a temperate forest landscape. [To be submitted to Ecosystems by June 2018]

3. Kobler, J., Kraus, D., Doktor, D., Lange, M., Kiese, R., Dirnböck, T. Comparing satellite-borne and modelled gross primary production in a mountainous forest landscape [to be ready by approx June 2018].

4. Kraus, D., Seidl, R., Dirnböck, T., Kobler, J. Thom, D., Kiese R. Impacts of climate change and forest disturbance on ecosystem services of forests in the P.A. Northern Limestone Alps. [to be ready by August 2018]

Doñana (Partner: EBD-CSIC)

5. Ramírez, F., Rodríguez, C., Seoane, J., Figuerola, J., Bustamante, J. How will climate change affect endangered Mediterranean waterbirds? PLoS ONE [To be submitted by February 2018].

Samaria National Park (Partner: FORTH)

6. Poursanidis, D., Gavish, G., Chrysoulakis, N., Ziv, G., Barnias, A., Spanelli, V., Lymberakis, P. Does grain size matter in species modeling for conservation decisions? [To be submitted 2018]

Gran Paradiso National Park (M1/M4) (Partner: EPFL, UFZ)

7. Dittrich, A., Cord, A., Entessa, C., Sonnenschein, R., Viterbi, R. Temporal transferability of remote-sensing based species distribution models in mountain areas [To be submitted 2018]

Peneda-Gerês National Park (Partner: ICETA)

8. Carvalho-Santos C, Marcos B, Regos A, Pallazi E, Monteiro AT, Nunes JP, Honrado JP Hydrological impacts of fires under scenarios of climate change: modelling approach using SWAT model. [To be submitted to HEES - Hydrology and Earth System Sciences by August 2018]

9. Monteiro AT, Alves P, Mitchell A, Carvalho-Santos C, Arenas-Castro S, Gonçalves J, Lucas R, Cunha M, Walz A and Honrado JP. Earth observation on the accomplishment of grassland biodiversity targets in Southern European protected areas during major societal developments in Europe [To be submitted very soon to Remote Sensing]

Har Hanegev (A1) (Partner: BGU)

10. Yizhaq, H., Shachak, M., Ehud, M. Modeling Har-HaNegev Terraced Riverbeds [To be submitted approx. 2018]

Murgia Alta (A3) (Partner: CNR)

11. F. Casella, F. Diele, D. Lacitignola, C. Marangi, A. Martiradonna, A. Provenzale, Mathematical tools for controlling invasive species in Protected Areas, to be submitted within two weeks in a Springer INDAM book of proceedings of MAC2I, March 2017, Rome

12. C. M. Baker, F. Diele, C. Marangi, A. Martiradonna, S. Ragni, Optimal control governed by a diffusion PDE with Holling type II reaction term and budget constraint, to be submitted by the end of february on a special issue of Natural Resource Modeling

Lakes Orhid and Prespa (M5) (Partner: UP)

13. Markovic, D., et al. Modelling chlorophyll-a concentrations in Lakes: Water Quality Drivers, Recent Changes, Status and Trends across European Lakes from Mountain Regions [will be ready to submit approx. February 2018]

Sierra Nevada (M8/M9) (UGR)

14. Moreno, R., Herrero, J., Bonet-García, F. J., Millares, A. Temporal evolution of ecosystem services in Sierra Nevada for informing land-use decisions. [will be ready to submit approx. May 2018]

15. Suárez-Muñoz, M., Bonet-García, F.J., Hódar J.A., Herrero, J., Tanase, M. INSTAR: an Agent-Based Model to simulate the biological cycle of forest pests in Mediterranean ecosystems. [submission expected during spring 2018]