A Review Paper on Biodiversity Monitoring

[1]Dr. Anshu Choudhary, [2]Dr. Neha Yajurvedi, [3]Dr. Neha Vashistha
[1,2,3] Shobhit Institute of Engineering and Technology (Deemed to be University), Meerut
Email Id- [1]anshu@shobhituniversity.ac.in, [2] nehayajurvedi@shobhituniversity.ac.in
[3]nehavashistha@shobhituniversity.ac.in

ABSTRACT: Human activity and land-use change are drastically changing the proportions, geographical distributions, and functioning of biological communities throughout the globe, with far-reaching implications for human well-being. However, our capacity to detect, monitor, and predict biodiversity change – which is critical to human survival – is limited addressing it - the options are still restricted. To enhance biodiversity monitoring, new systems are being created. This capability is achieved by extracting change metrics from a variety of in situ data (for example, field plots or species) and observations of the Earth (EO; e.g. satellite or airborne imagery). However, there are few ecologically based frameworks for converting this data into useful measures of environmental impact. Changes in biodiversity in this paper, the ideas of pattern and scale may be used to ecology. To construct such a structure the author has discuss three main topics: the importance of scale in measuring and modelling biodiversity patterns using EO, scale-dependent difficulties in connecting in situ and EO data, and scale-dependent challenges in integrating in situ and EO data. Pattern and scale ideas may be used to EO to enhance biodiversity mapping. An actionable method for measuring, monitoring, and predicting emerges from this study. The importance of establishing EO as the backbone of globalscale, science-driven conservation is shown by the shift in biodiversity.

KEYWORDS: Biodiversity, Ecosystem, Environment, Global, Monitoring.

1. INTRODUCTION

Global biodiversity monitoring is a vital but challenging task, since human activities are altering the structure and composition of biological population’s at all taxonomic levels. Mitigating biodiversity loss will require understanding the rates, magnitudes and geography of these alterations. However, given the breadth of activity needed for mitigation, our understanding of global biodiversity alteration is modest. Furthermore, what is known about biodiversity change is complicated by taxonomic, regional and temporal scale biases. Novel biodiversity monitoring methods are being developed to systematically evaluate change for many taxa over big extents. To Several organizations have come up with new ways to support these systems. Methods for tracking species, groups, and ecosystems utilizing globally consistent change measures. These measurements are biological and changeable and environment agnostic, allowing for global consistency in monitoring protocols. These initiatives have resulted in Increased availability to globally available in situ biodiversity observations has significantly aided this effort. However, since in situ data are insufficient. For evaluating global diversity trends, it is often inadequate (sense). Researchers have been looking for more data since 2010 to support their findings. Support efforts to monitor observations of the earth (EO; e.g. satellite or airborne imagery) repeat, thematically related data to supplement in situ data. Terrestrial ecosystems are being measured in a consistent and geographically continuous manner to characterize biodiversity trends across time. Big, under-represented regions Linking field and EO, on the other hand, is a difficult task. There are many difficulties that data must overcome. Overcoming incomplete sampling attempts (i.e. when field measurements do not match) is one of them [1]–[7].

Characterize the amount of environmental variation adequately:

Both ecology and EO research rely heavily on scale, and Identifying common scaling processes may serve as a foundation for future research. Bridging the gap between these fields Understanding the functions of space the importance of spatial and temporal scales in biological communities cannot be overstated. The issue of pattern is a subject in ecology that is referred to as the pattern problem. As well as size, Pattern Recognition Issues The fact that several ecological processes are frequently occurring at the same time emphasizes the importance of scale. Influence biodiversity patterns, and that these processes may operate in a positive or negative way over a wide range of geographical and organismal. As a result, a single measuring scale is seldom used. That most accurately reveals how particular processes influence patterns

Hutchinson. Similar scale dependencies apply to EO measurements: the grain size of an EO sensor frequently determines which patterns may be detected as well as multi-scale analysis. Multiple mechanisms may be revealed via EO analysis driving patterns of biodiversity. Applying ecological ideas of pattern and scale to EO may offer a way to better connect various areas, opening the way for further collaboration. Paving the path for better biodiversity monitoring in this article, I go through the many scales on which EO has been utilized. Monitor and simulate biodiversity change measures, as well as the importance of scale in tying field data to EO this isn't technically true an overview of the types of biodiversity patterns that EO can detect (sensu) [8]–[11].

Rather, these three questions are addressed in this review:

- At what scales has EO been used to assess or simulate spatial patterns in the present and past? What are the patterns of biodiversity?
- What are the most significant obstacles to linking field-based and EO-based biodiversity measurements, what effect does size have on these issues?
- How might the use of pattern and scale concepts to EO help to translate biodiversity trends across scales? The goal of this project is to

To include EO into biodiversity monitoring systems on a larger scale, and to support conservation initiatives that are based on research.

1.1 Pattern and Scale Components in Ecology:

In ecology, research on pattern and scale focuses on two different but related measuring scales: grain size and expanse. I use these scales in a geographic context in my review whereas the frequency may be described by the temporal grain size. The number of observations (e.g. one diurnal cycle for net primary productivity) and temporal extent could describe the total time span which an ecological process (for example, phenological fluctuation) takes place throughout the course of the year). I also use the classes and metrics of biodiversity change from the Essential Biodiversity Index. This framework captures the multiple biological scales of diversity (i.e. variation in genes, species, communities and ecosystems) as opposed to a more narrow interpretation that refers to biodiversity as variations in species richness, abundance and evenness. I believe these disaggregated classes and metrics more comprehensively address the patterns that can be measured and modelled using EO. In this section, the author has discuss how concepts of pattern and scale in ecology apply in biodiversity and EO contexts, then the review domains of scale, which constrain efforts to generalise patterns across scales. Changing measurement scales. Measurement scales are often selected to understand biodiversity patterns or ecological processes at a specific scale or set of scales. A key scaling dynamic is that when the scale of measurement changes, the variation within that measurement is also subject to change. For example, early biodiversity/ecosystem function research suggested the relationship between species richness and productivity to be “hump-shaped”, predicting peak biomass accumulation at intermediate diversity for both primary and secondary productivity. However, this functional form was shown to be an artefact of plot size as opposed to any ecological process, and a global synthesis found mixed evidence for a generalised relationship. Recently, long-term studies addressing scale directly have demonstrated a positive diversity-productivity relationship in multiple ecosystems. Measurements of community-scale patterns, like species richness and turnover (i.e. alpha and beta diversity), have also been shown to vary directly with scale. Coarse grains are expected to contain higher species richness per grain, and thus lower species turnover between grains. This is because larger grains are expected to contain more rare species and more environmental variation showed systematic increases in species richness at coarser grain sizes for birds in South Africa and Australia. Similarly, species turnover has been shown to decrease at coarser grains for birds in Britain and North America, and for mammals in Mexico. Figure 1 shows the Log–log plot of spatial and temporal and grain sizes for 44 current and historic satellite Earth observation (EO) sensors, coloured by biodiversity pattern type.

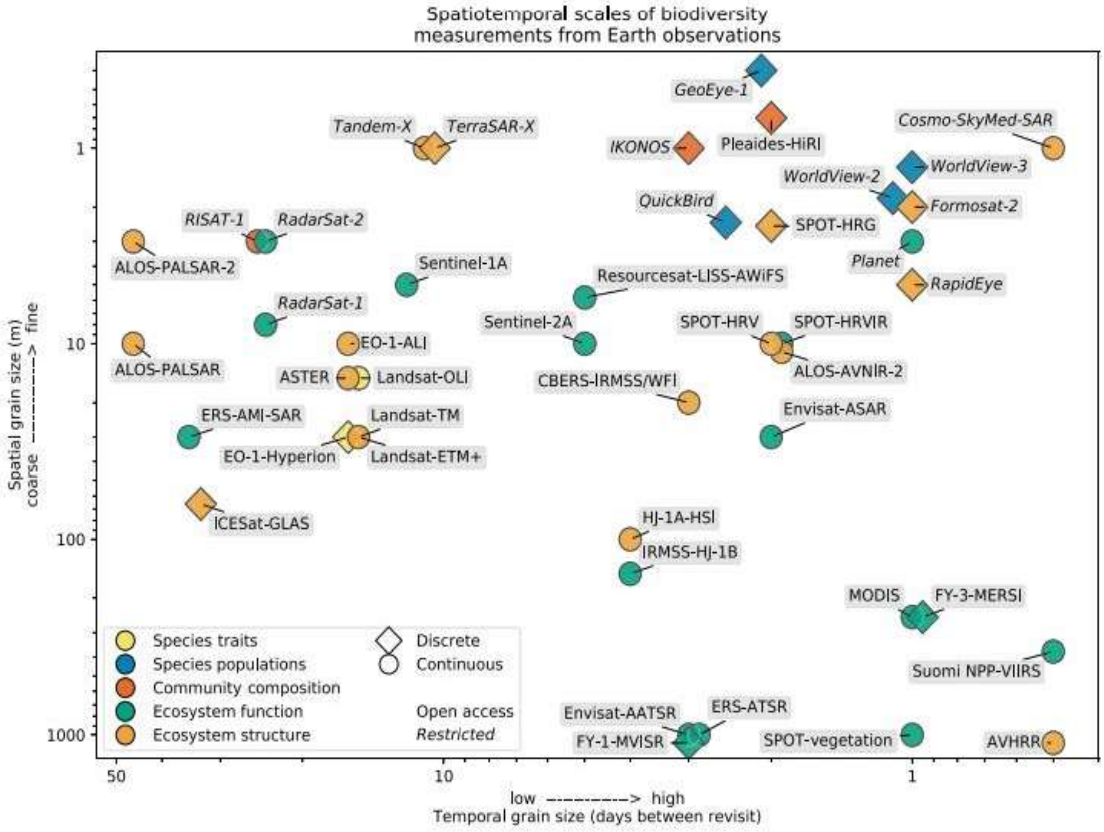

Figure 1: The above figure shows the Log–log plot of spatial and temporal and grain sizes for 44 current and historic satellite Earth observation (EO) sensors, coloured by biodiversity pattern type.

Measurement scales likewise determine which biodiversity, EO can measure patterns generally; fine grain sensors measure species- and community-scale patterns like species occurrences and taxonomic diversity. Measuring species traits has proven challenging due in part to difficulties distinguishing individual organisms in EO imagery. However, some plant traits, like canopy nitrogen content and photosynthetic rates, can be measured at moderate grain sizes. High frequency measurements can map temporally sensitive processes like vegetation phenology, but high frequency, continuous measurements often come at the expense of coarser grain sizes. Coarse grain EO sensors measure ecosystem-scale patterns, like disturbance regime and ecosystem extent. Satellite EO have historically focused on measuring ecosystem-scale patterns, due to the grain sizes of historic sensors, but the increasing number of fine-grain EO sensors in orbit could shift EO biodiversity mapping to focus on more species- and community-scale patterns.

1.2 Measuring biodiversity patterns:

Sensor type, sensor fidelity, and measurement scales are three important characteristics of EO assessments of biodiversity patterns. Sensor type defines which patterns may be detected, sensor fidelity limits the variance in those measurements, and measurement scales control the degree of variation within and between measurements. Multispectral sensors and imaging spectrometers are often used to assess patterns of ecosystem function, such as leaf area index, vegetation phenology, and disturbance regime. Active sensors, such as radio or light detection and ranging sensors, are often used to assess patterns of ecosystem structure, such as tree height and ecosystem extent. Multiple sensor types have been employed to measure the same pattern, thus these differences are not axiomatic. For example, tree cover has been measured using both radar and multispectral sensors. Multispectral sensors map tree cover by detecting leaf optical features including pigment concentrations, whereas radar sensors map tree cover by assessing woody structural and hydrological parameters.

Multi-sensor fusion is a technique for improving model accuracy and reducing sensor-specific uncertainties by combining several sensors to map a single biodiversity pattern. This method has been used in the mapping of tree cover. Despite the fact that multispectral sensors are sensitive to pigment concentrations, assessing tree cover under leaf-off circumstances is difficult since exposed branches seem to be dry grass or other non-photosynthetic plants (Asner 1998). To avoid this problem, the author has used a combination of multispectral and radar data to map cover in a South African savannah. Radar is sensitive to woody biomass independent of phenology, although speckling may make it loud. They were able to map tree cover with 90 percent accuracy by combining these two sensor types, which was 12 percent better than using each sensor alone.

Multi-sensor fusion methods to biodiversity mapping have a lot of potential for minimizing sensor-specific uncertainties, and they are only going to get better as more sensor types become available. The relevance of scale in detecting biodiversity patterns has been assessed by comparing data from identical sensor types with various grain sizes. The author examined NDVI data from four space borne multispectral sensors and found that differences in grain size were responsible for up to 20% of the measurement variation across sensors. Furthermore, discovered that variations in grain size accounted up to 50% of the variance in multi-scale leaf area index measurements, with the amount of variance increasing with coarser grains and in spatially diverse landscapes. When these spatial uncertainties are compared to the radiometric calibration uncertainties of EO sensors (i.e. sensor fidelity), which are typically between 5 and 10% absolute radiance, it appears that differences in measurement scales can be just as important for mapping biodiversity patterns as differences in sensor fidelity.

Radiative transfer models have been used to investigate the physical causes of scale dependency, especially for patterns of ecosystem function.

1.3 Modelling biodiversity patterns:

Patterns of biodiversity that are difficult to quantify directly with EO are often modelled as a function of environmental factors. Models of species-scale, community-scale, and ecosystem-scale biodiversity patterns are among the numerous methods to modelling biodiversity patterns using EO. Following multi-scale sensitivity analysis, these methods generally resample all data layers to a consistent grain size and extent. Models of individual species distributions and community-scale patterns like alpha and beta diversity are briefly discussed here. These modelling techniques have already been discussed elsewhere; however, this section focuses on the impact of scale in these methods.

Species distribution models (SDMs) forecast species distributions across a large area based on environmental factors that limit habitat availability and usage. Although feature selection has received a lot of attention in SDM. Several significant reviews have emphasized that scale selection may be just as essential. Even yet, studies that explicitly address scale have shown mixed outcomes for example, modelled bird and plant distributions at various grain sizes and found relatively minor reductions in model accuracy with coarser grain sizes on average. When these results were broken down by taxon, however, it was discovered that all plants, but not all birds, had significant decreases in accuracy at coarser grains. Furthermore, the species with the smallest amount of training data saw the greatest reductions in accuracy. Investigated these trends further in nine plant species, comparing model accuracy and geographical distribution patterns. They discovered that model accuracy dropped regularly as grain size increased, and that these drops were species-specific. The author has discovered substantial geographical disagreement across models of changing grain size for each species, which may have important implications for spatial conservation planning.

When using EO to model community-scale patterns, there are two main approaches. To estimate community composition, first predict the distributions of all species in a community, and then overlay these outputs. The second method is to use regression to predict community diversity measures. The relevance of scale in various methods has been ambiguous, as previously stated, for example, used a stacked-SDM method to simulate different plant community diversity indicators in the French Alps at various grain sizes. They discovered that changes in grain size had no effect on estimates of functional diversity, phylogenetic diversity, or species richness. Functional diversity was best predicted at the smallest grain size (250 m), whereas phylogenetic diversity and species richness were best predicted at the largest grain size (1000 m), indicating that scale dependency at the community scale is often process specific.

Comparing species richness estimates across several sensors has been used to assess scale dependency in regression methods. The characteristics from a fine grain, low fidelity sensor (IKONOS) and an intermediate grain, high fidelity sensor to predict plant species richness (Landsat). Because community diversity measures look at both within- and between-grain variation, fine-grain EO should be able to anticipate these trends better. High-fidelity measurements, on the other hand, may be able to better distinguish between-grain variation in environmental variables that predict community spatial turnover. Despite the coarser grain size, they found that Landsat-based models accurately predicted plot-level species richness. Despite the fact that the IKONOS data matched the grain size of the field plots, they were unable to distinguish spatial variation in environmental variables that predicted spatial richness patterns. Separating the impacts of sensor fidelity from different measurement scales will make it easier to distinguish sensor dependency from scale dependence when modelling other biodiversity trends.

2. DISCUSSION

Human activities and land use change are drastically changing the sizes and geographical ranges of species affects the functioning of biological communities throughout the globe, with far-reaching implications for human health well-being. However, our capacity to detect, monitor, and predict biodiversity change – which is critical to human survival – is limited addressing it - the options are still restricted. To enhance biodiversity monitoring, new systems are being created. This capability is achieved by extracting change metrics from a variety of in situ data (for example, field plots or species occurrence records) and observations of the Earth (EO; e.g. satellite or airborne imagery). However, there are few ecologically based frameworks for converting this data into useful measures of environmental impact. Changes in biodiversity in this paper, the author has shown how the ideas of pattern and scale may be used to ecology.

To construct such a structure discuss three main topics:

the importance of scale in measuring and modelling biodiversity patterns using EO, scale-dependent difficulties in connecting in situ and EO data, and scale-dependent challenges in integrating in situ and EO data. Pattern and scale ideas may be used to EO to enhance biodiversity mapping an actionable method for measuring, monitoring, and predicting emerges from this study the importance of establishing EO as the backbone of globalscale, science-driven conservation is shown by the shift in biodiversity. According to a review of landscape-scale research, biodiversity responses to habitat fragmentation are more often beneficial than negative, and the widespread belief in negative fragmentation effects is a "zombie notion," the report says. We show that bridging the scientific gap and effectively informing conservation would need research beyond statistical and correlational techniques.

3. CONCLUSION

The Internet's enormous repository of dispersed, raw biodiversity data will set the tone for how biodiversity trends are studied in the future. Numerous instances already show the vast potential of such data when analyzed and interpreted in the context of geospatial data as part of the emerging discipline of business intelligence. Nonetheless, the demands that these technological advancements will place on the shoulders of the taxonomic and systematics communities will be significant—in fact, without a strong and active taxonomic community, BI will never be more than a clever set of software tools with no substantial factual basis. The presence and passionate involvement of an active community of taxonomists are required for the detection of issues such as synonyms, misidentifications, dereferencing discrepancies, obsolete taxonomy, and so on. More importantly, these advancements are contingent on adequate support for the world's fundamental infrastructure of museums and herbaria— these institutions provide the world's key infrastructure of biodiversity knowledge, and they are becoming increasingly endangered because of cost-cutting bureaucrats.

REFERENCES

[1] J. Soberón and A. T. Peterson, “Biodiversity informatics: Managing and applying primary biodiversity data,” *Philosophical Transactions of the Royal Society B: Biological Sciences*. 2004, doi: 10.1098/rstb.2003.1439.

[2] C. B. Anderson, “Biodiversity monitoring, earth observations and the ecology of scale,” *Ecology Letters*. 2018, doi: 10.1111/ele.13106.

[3] G. E. Garrard, N. S. G. Williams, L. Mata, J. Thomas, and S. A. Bekessy, “Biodiversity Sensitive Urban Design,” *Conserv. Lett.*, 2018, doi: 10.1111/conl.12411.

[4] R. J. Fletcher *et al.*, “Is habitat fragmentation good for biodiversity?,” *Biological Conservation*. 2018, doi: 10.1016/j.biocon.2018.07.022.

[5] Q. Q. Wu, Z. S. Liang, J. J. Liu, M. J. Yu, and G. Hu, “Effects of habitat fragmentation on biodiversity in China,” *Chinese Journal of Ecology*. 2017, doi: 10.13292/j.1000-4890.201709.012.

[6] P. A. Sandifer, A. E. Sutton-Grier, and B. P. Ward, “Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation,” *Ecosystem Services*. 2015, doi: 10.1016/j.ecoser.2014.12.007.

[7] H. Hillebrand *et al.*, “Biodiversity change is uncoupled from species richness trends: Consequences for conservation and monitoring,” *J. Appl. Ecol.*, 2018, doi: 10.1111/1365-2664.12959.

[8] P. Vihervaara *et al.*, “How Essential Biodiversity Variables and remote sensing can help national biodiversity monitoring,” *Glob. Ecol. Conserv.*, 2017, doi: 10.1016/j.gecco.2017.01.007.

[9] C. Bellard, C. Bertelsmeier, P. Leadley, W. Thuiller, and F. Courchamp, “Impacts of climate change on the future of biodiversity,” *Ecology Letters*. 2012, doi: 10.1111/j.1461-0248.2011.01736.x.

[10] V. Proença *et al.*, “Global biodiversity monitoring: From data sources to Essential Biodiversity Variables,” *Biol. Conserv.*, 2017, doi: 10.1016/j.biocon.2016.07.014.

[11] D. S. Schmeller *et al.*, “A suite of essential biodiversity variables for detecting critical biodiversity change,” *Biol. Rev.*, 2018, doi: 10.1111/brv.12332.