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Tree Planting and its effects on biodiversity in Opak-Oya River basin: One year after the plantation

T B Adi¹, Guntur D R¹, Okryreza A¹, Muhammad B¹, Irfan Rosyadi², Fernadi¹, Erry K W¹, Fajrin Fahmi² & Arif Rudiyanto²

¹ Terminal BBM Rewulu – PT. Pertamina (Persero) Marketing Operation Region IV

² Yayasan Kanopi Indonesia, Karangmloko, Sariharjo, Ngaglik, Sleman, Yogyakarta

tunjung.adi@pertamina.com

Abstract. Opak River watershed is one of the river watershed in special region of Yogyakarta Province which has important role as water reserve for the community. The eruption of Merapi volcano that often occurs has damaged riparian ecosystem of the rivers in Opak river watershed. To restore Ecosystems in Opak river watershed Conservation during 2016-2018. Tree planting have been conducted five times in riparian ecosystem and Mangrove ecosystem during 2016-2018, At least 17000 individuals have been planted in tree area comprising (5000 individual of 25 species in upstream, 2000 individuals of six species and 10000 individuals of *Rhizophora* spp. Biodiversity survey have been conducted two time in July-August 2017 and April 2018 at three area in Opak river watershed (up stream, middle stream and down stream). The results shows a total of 291 species of plants, 84 birds species, 18 species of herpetofauna, 10 species of mammals, 35 species of fish, 206 species of insects, 26 species of macrozoobentos (mollusca), and 113 species of plankton in three study areas has been identified in Opak Watershed during 2017-2018. The presence of species in each study area as well as the composition of the number of individuals per species is shows difference between the survey in 2017 and 2018 .This is also showed in the number of those diversity indexes. This Biodiversity monitoring is planned to be continued least 5 times which will be conducted in every years.

1. Introduction

The Oyo-Opak River Watershed is one of the river watershed in DIY Province other which covers 637.5 km² [1]. It serves as a buffer for the water needs of 3,304,229 peoples [2] in four regencys and cities in Special Region of Yogyakarta, covering Sleman Regency, Yogyakarta City, Bantul Regency, and Gunungkidul Regency.

The upstream Opak River Watershed is located on the slopes of Merapi volcano, flows through many rivers that cross the Yogyakarta region, such as Kali Kuning, Kali Gajah Wong, Kali Opak and Kali Gendol. The eruption of Mount Merapi that often occurs in the 4 year period is always followed by cold lava flood that has caused the changing of the river landscape including the destruction of trees growing on the edge of the river (riparian ecosystem). In addition, community activities that utilize rivers and watershed also cause changes in riparian ecosystems.

To repair the riparian ecosystem, communities, institution, and national company have conducted tree planting in the particular area along the Oya-Opak river. During 2016-2017 PT. Pertamina (Persero) TBBM Rewulu and Yayasan Kanopi Indonesia, involving local people have conducted tree



planting in riparian river ecosystem and mangrove ecosystem to improve the river ecosystem quality. The trees that planted in the area was various such *Dracontomelon sp.*, handkerchief (*Maniltoa grandiflora*), gayam (*Inocarpus fagiver*), salam (*Syzygium polyanthum*), puspa (*Schima wallichii*), asam turgo, damar (Agathisdammara), cloves (*Eugenia aromaticum*), *Psidium guajava*, avocado (*Persea americana*), durian (*Durio zibethinus*), Polynesian chestnut (*Inocarpus phagiferus*), *Rhizophora sp.* (mangrove area or downstream), and 25 species of bamboo.

The tree plantation gives various effects on the ecosystem, particularly about biodiversity. It also provide various habitat dan food for animal and other organisms when the seedlings planted becomes saplings or trees. The animal such insects, which very specific about host plant, will take place on the new tree seedling [3]. The trees also give effect on the watershed because the trees serve energy in detritus form to the watershed [4]. Generally, the tree planting will provide feed, habitat as well microclimate for another living thing [5]. This paper was aimed to indentify the biodiversity condition one year after tree planting activity that has conducted by PT. Pertamina in 2016 and 2017. The data collection would be continued annually at least during 5 years after the plantation or until 2021.

2. Methods

2.1. Study Area

Baseline data Biodiversity is developed in 2017 and by 2018 biodiversity monitoring is taking place and taking place in three areas in the Opak watershed including upstream, downstream and central parts. The upstream area occurs in the Kali Kuning river watershed at Plunyon, Cangkringan district located in the buffer zone of Gunung Merapi National Park. In the middle stream is underway at the point of the river meeting Kali Kuning the river Oya and river Opak in Imogiri district Bantul regency. These study is considered as urban area which was damaged by flood in December 2017. While downstream is the estuary area, in Baros village Kretek distric Bantul regency. The mangrove in this area was began to be developed since 2003 by a local group of KP2B and NGO Relung [6].

2.2. Materials and Data Collection

To obtain information on biodiversity wealth in the Opak Watershed, baseline data will be made at the beginning of the activity and will be monitored for biodiversity every year. Monitoring is focused on several groups of organisms that include flora, birds, insects, herpetofauna and mammals, fish, macrozoobenthos, and plankton.

The data collection was carried out through sampling method which is different between each study group. Plant data sampling was collected using square quadrat plot method with nine sample in every area, with th size of 10mx10 m for tree and sapling and 1 m x 1 m for floor vegetation. For the bird we used encounter rate method which was combined with mackinnon list [7], we utilized binocular to observe bird. Insect data collection was using exploring method by using sweepnet. For plankton, we used shallow water plankton method by utilize plankton net, and bucket at the six station with tree replication each area. Species counting and identification was conducted in laboratorium using microscop. Macrozoobentos, we used direct sampling to collect the data by immersing a macrozoobentos grab sampler with the size of 20x20X20 cm in to the substrate. All substrates in the box are removed with a shovel, then stored in a plastic bag. The separation between macrozoobenthos and substrate was conducted in a field laboratory with the help of water and a 1 mm sieve. Mammal and herpetofauna, we used exploring method to cover the area and using encounter rate to collect the data fauna darat (herpetofauna dan mamalia).

2.3. Data analysis

The number of species and its number of individual which is recorded from in each study area was analyzed using the Shannon-Wiener's diversity index.

$$H' = - \sum p_i \ln p_i \quad (1)$$

as $p_i = n_i/N$, where n_i is the number of individuals in species i and N is the total number of individuals in the community [5].

$$E = \frac{H'}{\ln(S)} \quad (2)$$

Where: e' = Index of evenness type H' = Index Shannon S = Type found \ln = Natural logarithm.

If the higher 'E' indicates the types in the community are spreading further. Based on [8] the amount of $R1 < 3.5$ indicates a relatively low species richness, $R1 = 3.5 - 5.0$ indicates that the species richness is moderate and $R1$ is high if > 5.0 .

The $H < 1.5$ scale indicates that species diversity is low, $H' = 1.5 - 3.5$ indicates species diversity is moderate and $H' > 3.5$ indicates high diversity. The magnitude of $E < 0.3$ indicates evenness type is low, $E' = 0.3 - 0.6$ Evenness type is classified and $E' > 0.6$ then equally type pertained high.

3. Results

In early 2017 data collection has been identified 163 species of flora, 61 species of birds, 128 species of insects, 10 species of herpetofauna, 4 species of mammal, 18 species of fish, 26 species of macrozoobenthos and 91 species of plankton. While from the monitoring in 2018 found 194 species of flora 59 species of birds 139 species of insects, 6 species of herpetofauna, 3 species of mammal, 16 species of fish, 25 species of macrozoobenthos and 84 species of plankton.

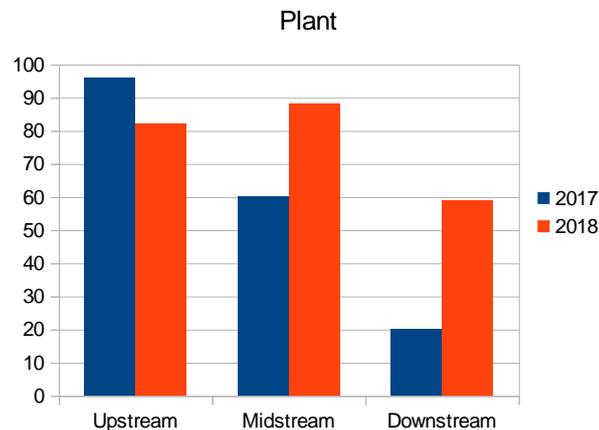
Table 1. Comparison of species in 2017 and 2018 in the Oyo-Opak River Watershed, Yogyakarta

No	Takson	Number of species	
		2017	2018
1	Flora (Plant)	163 species	194 species
2	Bird (Avifauna)	61 species	59 species
3	Insect	128 species	108 species
4	Herpetofauna	10 species	6 species
5	Mammal	4 species	3 species
6	Fish	18 species	16 species
7	Macrozoobenthos	26 species	25 species
8	Plankton	91 species	84 species

The presence of species in each study area as well as the composition of the number of individuals per species is shows difference between the survey in 2017 and 2018 . This is also showed in the number of those diversity indexes.

Table 2. Shannon-Wiener index and Evenness index of each taxa of study in the Oyo-Opak watershed in 2017 and 2018

No	Takson	Diversity Index			
		2017		2018	
		H'	E	H'	E
1	Plant	3,7	0,7	3,7	0,7
2	Bird (Avifauna)	2,3	0,6	2,49	0,57
3	Insect	2,5	0,7	3,68	0,48
4	Herpetofauna	0,9	0,3	1,43	0,92
5	Mammal	0,6	0,4	0,17	0,25
6	Fish	2,2	0,7	0,2	0,34
7	Macrozoobenthos	1,8	0,3	1,57	0,31
8	Plankton	3,4	0,7	3,23	0,61

**Figure 1.** Plant species in the upstream, middle and downstream in 2017 respectively of 96, 60 and 19 plants species and in 2018 respectively of 82, 88 and 59 plant species.

3.1. Plant

Vegetation in the upstream are typically consist of the species of sub mountain tree those who still survive during eruption in 2010 such as *Pinus merkusii* (pine), *Engelhardia spicata* (klewer), and *Schima wallichii* (puspa). There are also many pioneer plants such as *Piper anduncum*, *Mallotus paniculatus*, and *Macaranga* sp.. However there are many tree species which was planted at post-eruption 2010 such as the *Syzygium cumini* (duwet), *Inocarpus fagiferus* (gayam), *Erythrina variegata* (dadap srep), *Swietenia mahagoni* (mahoni) and *paraseriantes falcataria* (sengon). Vegetation in the middle stream area was dominated fruit plant and hard wood plantation which have economic value like *Tectona grandis* (Jati), *Dalbergia latifolia* (sono keeling), and *Acacia* sp. (acacia) and fruits such as *Mangifera indica* (manga), *Nephelium lappaceum* (rambutan), *Muntingia calabura* (talok), *Tamarindus indica* (asem), and *Carica papaya* (papaya). The downstream area that are near to Opak estuary was covered by mangrove vegetation which filled by *Rhizophora mucronata*, *Rhizophora apiculata*, *Avicennia marina*, *Sonnerita ovata*, *Bruguiera gymnorizza*, *Nypa fructicans*, *Derris trifoliata* and *Achantus ilicifolius*.

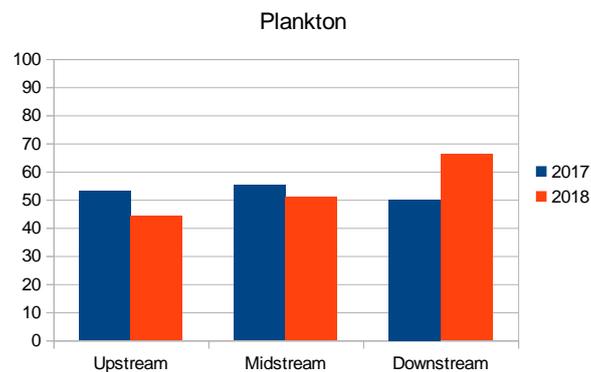


Figure 2. the number of macrobenthic species is always high from upstream to down stream

3.2. Plankton

Over all the survey showed that the number of phytoplankton species is always higher than zooplankton Species. In upstream area the survey in 2017 shows that the plankton was dominated by *Rhabdonema adriaticum* and *Navicular* sp., but in 2018 was dominated by *Spirogyra* sp. and *Diatome elongate*. In middle stream from the survey, in 2017 showed that *Diatome elongate* dominant but in 2018 the highest number of species is *Surirella* sp. while in down stream the survey in 2017 showed that *Campylodiscus* sp. was dominant but in 2018 was dominated by *Phrophacus* sp..

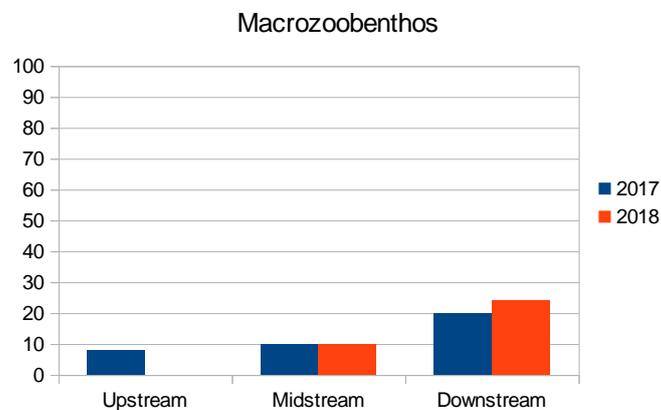


Figure 3. Number of macrobenthic species is increasing from upstream to down stream the species in the upstream, middle and downstream in 2017 respectively of 8, 10 and 20 species and in 2018 respectively of 0, 10 and 24 species.

3.3. Macrozoobenthos

Macrobenthic animal (macrozoobenthos) species was consist of the species from several organism group. Mollusca (bivalvia and gastropoda, malacostraca, insecta and oligochaeta. Gastropoda contribute the largest species, which some of them always come all area like *Assiminea* sp., *Melanoides* sp., *Pomacea* sp., *Sulcospira* sp., And some who only found in brackish water like *Faunus* sp., *Cerithideopsilla* sp., and *Cerithidea* sp.. The second is from Bivalvia such as *Saccostrea* sp., and *Veneridae* sp., Oligochaeta *Tubifex* sp..

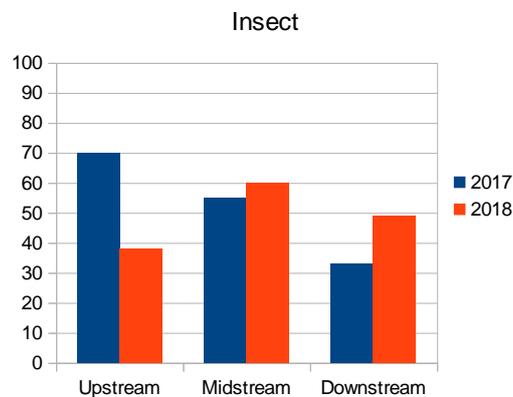


Figure 4. The monitoring have recorded species in the upstream, middle and downstream in 2017 respectively of 70, 55 and 33 species and in 2018 respectively of 38, 60 and 49 species

3.4. Insects

From the survey in 2017 and 2018 we found that the insect species in three area upstream, middle stream and down stream was dominated by predator and herbivor-polinator, the insect which is considered to be predator is such as *Mantis religiosa* (Mantodean), *Bicyrtes* sp., *Bembix* sp., *Oecophylla smaragdina* (Hymenoptera), *Orthretum Sabina*, *Agriocnemis femina*, *Neurothemis ramburii* (Odonata), *Coelophora* sp. (Coleoptera) and *Efferia* sp. (Diptera). The species of herbivor-polinator is mostly from Lepidoptera such as *Papilio memnon*, *Papilio demolion*, *Graphium Agamemnon*, *Hypolimnas bolina*, and *Junonia hedonia*.

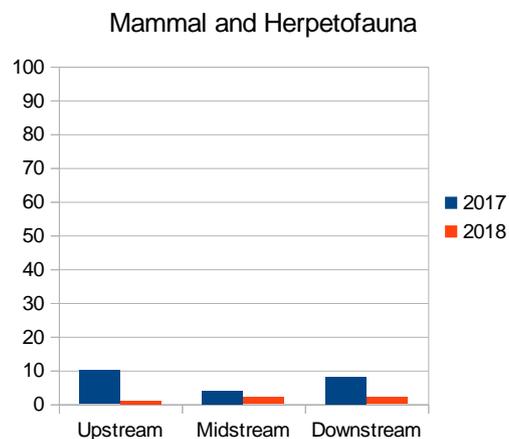


Figure 5. The monitoring have recorded species in the upstream, middle and downstream in 2017 respectively of 10, 4 and 8 species and in 2018 respectively of 1, 5 and 2 species.

3.5. Mammal and Herpetofauna

Mammal including plantain squirrel (*Callosciurus notatus*), megabats (*Cynopterus* sp. And *Macroglossus* sp.), javan mangoose (*Herpestes javanicus*), javan tree shrew (*Tupaia javanica*), and malayan field rat (*Rattus tiomanicus*). Herpetofauna including reptile and amphibia are found in a little number of 18 species. The amphibian are consist of *Occidozyga sumatrana*, (Dicroglossidae), *Fejervarya cancrivora* (Ranidae), *Polypedates leucomystax* (Rhacophoridae) and *Duttaphrynus*

melanostictus, *Ingerophrynus biporcatus*, *bufo asper* (Bufonidae). The reptile are consist of *Draco Volans*, *Eutropis multifasciata* (Scincidae) *Takydromus sexlineatus* (Lacertilidae), *Gekko-gecko*, *Hemidactylus frenatus*, *Gehyra mutilate*, *Cyrtodactylus marmoratus* (Gekkonidae), monitor lizard *varanus salvator* (varanidae), *Bronchocela jubata* (Agamidae), indo-chinese rat snake *snake ptyas corros*, painted bronzeback, *Dendrelapis pictus* (Colubridae).

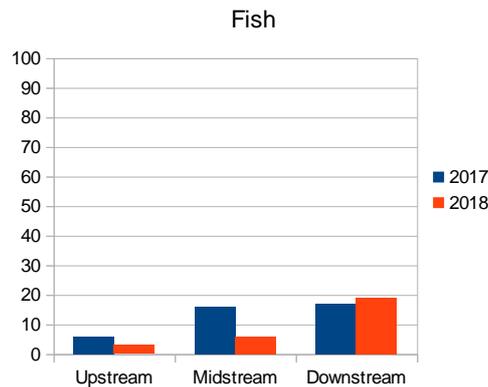


Figure 6. The number of species is increasing from upstream to down stream. The monitoring survey have recorded species in the upstream, middle and downstream in 2017 respectively of 6, 16 and 17 species and in 2018 respectively of 3, 6 and 19 species.

3.6. Fish

The fish species we found during the survey was consist fresh water species like *Puntius binotatus*, *Mystacoleucus obtusirostris*, *Nemacheilus fasciatus*, *Colossoma macropomum*, *Oreochromis niloticus*, *Mystus nemurus*, *Hypostomus plecostomus*, *Oreochromis mossambicus*, *Clarias batrachus*, *Xiphophorus helleri*, *Gambusia affinis*, *Poecilia reticulate*, estuarin species like *Chelon subviridis*, *Mystus* sp, *Scathophagus argus*, *Eriphthalamus argentilineatus*, mudskipper *Boleophthalmus* sp. and the species in estuary who originally come from the sea like *Ephinephelus tauvina* and *Caranx sexfasciatus*. During the survey We also found aliens species in the river Amazon sailfin catfish *Pterygoplichthys pardalis*.

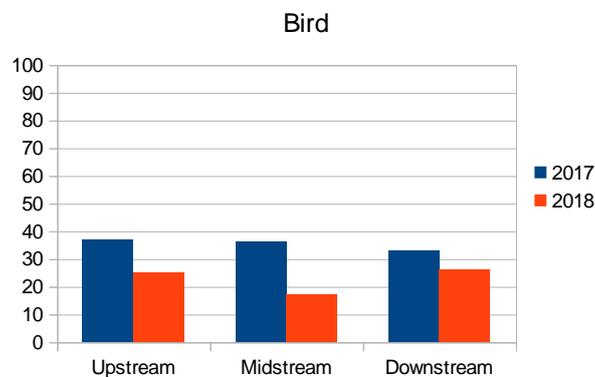


Figure 7. Bird species in the upstream, middle and downstream in 2017 respectively of 37, 36 and 33 bird species and in 2018 respectively of 25, 17and 26 bird species

3.7. Bird

The avifauna in the upstream (Plunyon, Kali kuning) characterized by forest bird birds that can still adapt red-breasted parakeet *Psittacula alexandri*, little pied fly-catcher *Ficedula westermanni* Striated grassbird *megalurus pulustris* raptors crested serpent eagle *Spilornis cheela*, spotted kestrel *Falco moluccensis*, in middle stream was characterized by the species which are adapted to the rural and agricultural landscape like javan munia *lonchura leucogastroides*, sooty-headed bulbul *Pycnonotus aurigaster*, common tailor bird *Orthotomus sutorius*, java kingfisher *halcyon cyanoventris*, while in the downstream which are covered by mangrove, lagune and agricultural the bird community was filled by scolopacidae Ruddy Turnstone *Arenaria interpres*, Wood Sandpiper *Tringa glareola*, Black-Crowned Night-heron *Nycticorax nycticorax*, javan Pond heron *Ardeola speciosa*, and javan coucal *Centropus nigrorufus*.

4. Discussion

The species present in upstream, middle and downstream was showing different trend among taxa. The monitoring in 2017 and 2018 shows the species of plants and insects was increasing from downstream to upstream. This situation is presumably caused by most insects has closely relation with plants especially for habitat of feeding roosting and breeding.

The plant species number in 2017 to 2018 is increasing but not followed by the diversity index. This condition indicates interaction among the tree. The trees planted might give effects on composition of the vegetation in the area. The change in plant species abundance typically occurs in floor vegetation (bushes and herbaceous). Floor vegetation are typically short-lived plants, which showing different species abundant on each season. During the long dry season only a few grass can live, while many others does not grow but still remains the tubers or seed in the ground, when the rainy season coming many seeds and tubers begin growing.

The insect and bird diversity index are showing increase from 2017 to 2018 but the species number and the evenness is showing decrease. This condition indicates the population of insect and bird species are changing. The diversity index is built by the proportion between species number and the population [5].

In bird species from upstream to downstream it is relatively stable but the species in the middle is always lowest. This situation is likely related to the location in the middle area which are relatively near to the rural settlement. while in upstream area is near to the national park forest providing a good habitat for birds, meanwhile in downstream is consist of coastal mangrove, lagoons and farmlands which provide habitat for diverse of birds species.

Species of fish and macrozoobenthos indicate the species was decreasing from downstream and upstream. River in downstream is deeper and wider than upstream makes it provide more substrate which is needed by benthos also provide more guild for lot of fish species.

However different situation was showed in plankton which the species relatively stable in high number from upstream and downstream. The plankton community in the river reflects its water quality. The abundance of phytoplankton in waters can provide information about the health of waterways that can be used as a basis in the management of certain locations [9].

According to the survey in 2017-2018, diversity index as well as number of species of the organisms that live in water (fish, plankton and macrozoobenthos) was decreasing. However, in water such macrozoobenthos, plankton, and fish get minor effect from the plantation directly. The river only get energy from detritus of the trees. The energy change need more time to be usable by the organisms [4].

The survey in 2017 and 2018 showed the herpetofauna diversity index are increase but the species and evenness are decreasing. Otherwise, the mammal diversity, species number, and the evenness are decreasing. Unfortunately the number of herpetofauna and mammal data in this research are very little. Data collection of herpetofauna and mammal were encounter rate through direct observation.

The results of monitoring indicate that the presence of species in all taxa decreasing from in 2017 to 2018, however the diversity index showing increasing which indicates that the composition of species and the number of individual per species is relatively more equal.

This presumably influenced by many things, (1) species mobility, especially in species with high mobility such as birds, fish, mammals (2) limited observation time or area sampling which affect the encounter rate (3) natural disturbance such as eruption with pyroclastic flow from eruption, floods, landslides, land clearing, (4) human disturbance such as pollutant, poison, hunting activity.

5. Conclusion

Based on the monitoring in 2017 and 2018 has been identified a total of 291 species of plants, 84 birds species, 18 species of herpetofauna, 10 species of mammals, 35 species of fish, 206 species of insects, 26 species of macrobenthic, and 113 species of plankton in three study areas in Opak River Basin.

Tree planting activities which is conducted during 2016-2018 likely to have no correlation with the declining as well as increasing of diversity index in all taxa in 2018. Tree planting activities which has been carried out in Opak River Basin would need long time to give impact in improving the quality of the environment including biodiversity.

Biodiversity monitoring in Opak river Basin still need to be continued annually within at least 5 years to give more information about biodiversity trend.

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