«Acoustic Ecology»: Journal

Introduction: Terms and Methods of Acoustic Ecology[1]

We meet on the roof of the *Zürcher Hochschule der Künste* for the first session of the lecture "Acoustic Ecology", right next to a pine measuring station of Marcus Maeder. Here, in the middle of Zurich, the conditions for pines are quite different from those in the Pfynwald forest in Valais, where long-term measurements of Scots pines were made as part of the research project "trees - making ecophysiological processes audible" and the extent to which environmental conditions manifest themselves acoustically in the trees was investigated. The fact that plants produce sounds has been known for some time in the research field of plant ecophysiology. Many acoustic signals are generated by water circulation during plant transpiration, i.e. the release of water vapor, and extend far beyond the audible range into the ultrasound spectrum.[2] The canton of Valais is particularly informative for research because, as one of the driest areas in Europe, it is already experiencing effects of climate change that are yet to come in the Alpine region.

> *Most of the sounds occurring in a plant occur in connection with drought stress. Thirsty plants make inaudible noise, acoustic emissions from plants allow conclusions to be drawn about their condition and environmental conditions. During our research project, we realized that our observation system could be used to experience another, more fundamental phenomenon: Namely, how trees react to increasingly prolonged periods of heat and drought in the wake of climate change.*[3]

Making processes audible, in this case ecophysiological processes that were initially imperceptible, is part of Soundscape Ecology. The term "soundscape" goes back to R. Murray Schafer in the 1960s, who started with his team the international research project "World Soundscape Project" with the aim «to find solutions for an ecologically balanced soundscape where the relationship between the human community and its sonic environment is in harmony.»[4] A soundscape exists through human perception of an acoustic environment. The sources of these sounds can be human, animal, or geological. As Marcus Maeder's research project demonstrates, sounds from plants can also be made audible to humans. A soundscape is created by these sound sources and their distribution in time and space. The Acoustic Environment is perceived, experienced or understood by a person in a specific context: The

---

[1] From the introductory lecture and presentation by Marcus Maeder, «Acoustic Ecology», FS20.
[2] ICST: *trees. Ökophysiologische Prozesse hörbar machen*: https://www.zhdk.ch/forschungsprojekt/426372. 5.12.20].
[3] Maeder: *Durstige Pflanzen machen unhörbaren Lärm*: https://zett.zhdk.ch/2017/08/30/marcus-maeder-durstige-pflanzen-machen-unhoerbaren-laerm/ [5.12.20].
[4] Wikipedia: *World Soundscape Project*: https://en.wikipedia.org/wiki/World_Soundscape_Project [5.12.20].

context, which includes the interactions between person and activity and place, could influence the soundscape through auditory sensations, their interpretation, or through immediate reactions, emotions, or behaviors to the acoustically perceived environment. Auditory perception is a function of neurological processes that begin as soon as auditory stimuli reach the receptors of the ear; it represents the first stage in the recognition of the acoustic environment and is influenced by masking, spectral content, temporal patterns, and spatial distribution of sound sources. The next stage of auditory perception is then the interpretation of this auditory perception, which refers to the unconscious and conscious processing of the acoustic stimuli to produce useful information that can lead to the understanding of the acoustic environment. In context, the perception of an acoustic environment constitutes an experience of the acoustic environment.

Soundscape Ecology now consists of interactions between anthrophones (the human-caused sounds), biophones (the sounds of animals), and geophones (the sounds of bodies of water or rocks). In Soundscape Ecology, soundscapes are captured and thereby ecosystems are observed. Sound is often represented visually in a spectrogram with a time axis on the horizontal plane and the frequency range on the vertical plane. Areas of research such as psychoacoustics, bioacoustics, spatial ecology, and acoustic ecology flow into the field of soundscape ecology. Psychoacoustics looks at human cognition, asking how we perceive the sounds around us and why we do so, while bioacoustics is devoted to animal communication, hearing, and vocalization. Spatial ecology studies the habitats of specific animals and plants in terms of their ecological processes. And Acoustic Ecology, with which we are concerned in this course, explores the acoustic interrelationship between living things and their environment. It classifies and systematizes sounds from recorded soundscapes. The diversity of sounds directly tells us something about the ecological state of a habitat: The more different sounds there are, the greater the diversity of animals. The so-called Acoustic Complexity Index serves as an indicator for biodiversity and shows the diversity of acoustic signals in a sound recording. An important part of Acoustic Ecology is the so-called Soundwalks, where groups explore a certain area, be it in the forest or in a city, with the help of microphones. In this way, listening is sharpened, and acoustic signals are described; one asks about the dominance of one sound in relation to the others, about the sensations that are awakened when listening or about the acoustic living conditions of the people, animals and plants found there.

In this course we will focus on the Glattpark area in the Zurich agglomeration, make audio recordings on site and interpret them acoustically, ecologically and artistically. On the one

hand we will make recordings with the help of microphones in the air and on the other hand with special audio sensors in the ground. We will ask about ecological connections and problems in urban agglomeration. How does traffic affect the fauna? What about the biodiversity in construction wastelands or how acoustically active are soil animals in urban gardening soils compared to allotment gardens? The results are then incorporated into a sound map that can be accessed online.

Research area Glattpark

Figure 1: Residential buildings and Glattparksee. Photo: Aline Stadler, Sept. 20.

We meet in Marcus Maeder's studio in the middle of Glattpark, next to SRF's TV tower. The Glattpark consists of many residential buildings, workplaces, recreational and sports fields, as well as a small forest, near the highway. The Glattpark area is a large construction project,

which was implemented from 2001 to 2020 and will provide space for about 7,000 residents and about the same number of jobs.[5]

After an introduction to recording technology, we walk through Glattpark and listen to the first soundscapes: Next to the remote recording studio there is the Leutschenbach, where a beaver lives (we see its burrow). At the entrance to Glattpark is the "Wunderkammer", an open space where the neighborhood, together with research institutes, sustainability initiatives, artists and social institutions, want to create "the new world on a small scale that we wish for on a large scale".[6] We listen here, right next to the Wunderkammer, with the Soil Recorder in the ground and with special audio sensors on the tree bark. We listen to insects. It is exciting to perceive the passing streetcar through the soil. You can also hear airplanes well in the ground, Maeder says. The Zurich airport is close to here; the planes sometimes fly only a few meters above the house roofs when taking off. We also visit a disused, fenced-off wasteland where a school building is to be built. The project is currently on track; thus a pond has formed in a gravel pit, reeds and many other plants attract animals.

Figure 2: First experiments with the recording devices... Photo: Aline Stadler, Sept. 20.

[5] Wikipedia: *Glattpark*: https://de.wikipedia.org/wiki/Glattpark [5.12.20].
[6] Web page *Wunderkammer-Glattpark:* https://wunderkammer-glattpark.ch/wunderkammer/ [5.12.20].

In small groups we make recordings in the following two sessions. In the first session we record 5 minutes each; next to a volleyball court where young people are playing, on a wooden bridge over the Glatt River where people are walking, or with special sensors in the Glatt River itself. In a second session, we mount devices in hidden places that record five minutes of the environment every hour for 24 hours. The settings and formatting are done via an app. We mount a recording device in the forest next to a pond and one under a fir tree - by now it is October, cold and rainy. We mount another recorder in the Opfikerpark, which consists of a large meadow, a broader stream in which people seem to go swimming in summer, with a small beach. Behind it are row upon row of residential houses. We mount the microphone on the bank of the stream in the immediate proximity of the reeds.

Analysis of the 24h-recordings: Forest

I focused on the analysis of the two 24-hour recordings in the forest under a fir tree and on the shore in the reeds. Let's listen to the recordings of the first recorder, which we mounted on the trunk of a fir tree in the forest of Glattpark, a few meters from a walking path. The individual files are available online on a soundmap: https://soundmap.kentai.ch/ and can be found in the Glattpark area in the upper part of the Vitaparcours (the coordinates can also be entered in the search: 47.421489 LAT, 8.572018 LON). The recording is titled "24h recording under a pine tree". It is worth listening to the recording with overheads (the low frequencies are astonishing).

Listening into each hour from that day, it is noticeable that traffic from the nearby highway is consistently perceptible. The cars and trucks are, in my opinion, surprisingly dominant in the overall soundscape surrounding the fir tree, both at night and during the day. On the evening of October 26, 2020, the rain in particular can be heard on the first recordings, as well as church bells ringing, a passing bicycle, and now and then teenagers probably playing sports games at the adjacent "Sportanlage Au". From 20 to 21 o'clock it becomes basically quieter, at the same time into the night many single trucks become audible, which drive past. After midnight it seems to get quieter again, you can hear branches possibly falling down, then movements on the forest floor, probably small nocturnal animals ¬- in the recording at 03 o'clock in the morning, for example, there is (besides the three chimes at the beginning) a beeping at minute 03:31. And soon the first birds begin to sing. It becomes increasingly louder again from 04 o'clock, the morning traffic can already be heard and becomes strongest at 6 and 7 o'clock. At 7 and 8 o'clock we hear various bird songs, moving animals and also a person passing by. In the morning, the low-frequency, dull traffic noise remains recognizable,

few birds and movements of other small animals. There are also people walking or jogging by. Very present are wind and rain from 12 to 14 o'clock. In the afternoon, several sounds come together, but it is not louder than in the morning; The traffic on the highway and individual birds can still be heard, once an airplane, a motor vehicle approaching and once apparently handicraft work is performed or a lawn mower is used. Finally, towards the end of the day, it gets a bit louder again.

I analyze the recordings with the program Avisoft Bioacoustics, a software for the study of animal sound communication. The program calculates the acoustic complexity of each of the 24 files, i.e. it registers the variety of acoustic signals. Based on the average of the calculated data resulting from the files, I create a diagram. This roughly represents the course of the acoustic complexity over the 24 hours.

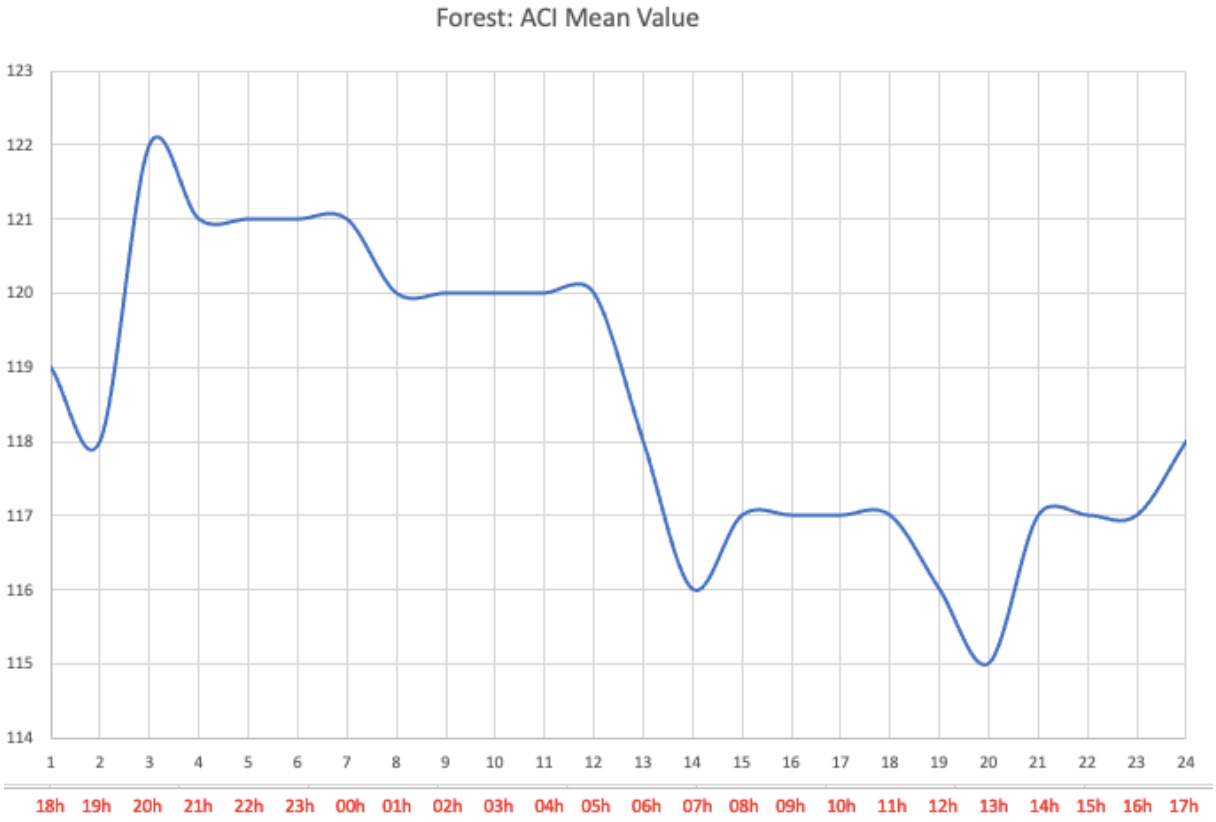

Figure 3: Acoustic Complexity Index, kurz: ACI (y-Achse), der im Wald entstandenen Aufnahmen vom 26. Oktober 2020, 18 Uhr, bis 27. Oktober 2020, 18 Uhr (x-Achse), Glattpark bei Zürich.

So here we see the progression of the Acoustic Complexity from October 26, 2020 at 6 pm to October 27, 2020 at 6 pm. For the Acoustic Complexity Index, the higher the value, the more different sounds are present. (The value of the ACI, for example "120" here, represents a logarithm and does not represent the effective number of acoustic signals captured.) What we see is an increase in the variety of sounds from 7pm to 05am. Thereafter, acoustic complexity

drops and reaches its lowest point around midday before rising again. How far can this dynamic be heard on the recordings? It is noteworthy and interesting that the ACI is higher at night than during the day. I think this is due to two reasons: First, the traffic of the highway is still there, but it now leaves room for the sounds in the forest; you can hear "something happening" around the pine tree; animals, raindrops, branches. At the same time, the traffic noise seems to be perceived in a more differentiated way; one hears individual trucks rather than many cars at once, as is the case during the day. Still, it is surprising that bird songs do not produce a higher ACI in the morning. I explain the lows of the ACI around noon by the present wind drowning out other voices. Since weather conditions also have a significant influence on the recordings (these are sensitive microphones), a recording project over several weeks or months would be particularly informative in order to be able to make comparisons and establish tendencies.

Analysis of the 24h recordings: Reed

The other of the two locations is between the long Glattparksee and a large grassland that is well frequented and used for playing in the summer. On the shore, in the immediate proximity of the reeds and next to a walking path, we mounted the recording device. The recordings can be found on the soundmap https://soundmap.kentai.ch/ under the coordinates 47.422675 LAT, 8.565942 LON. Again, I am surprised by the loudness of the traffic, which is present throughout. From 6 p.m. to 8 p.m., the motorway is quite dominant; otherwise, one notices a lapping of the water and people passing by. From 9 p.m. onwards, the traffic is less dominant, one hears the water better and increasingly also moving animals (perhaps nibbling something or communicating with each other?). From midnight to 4 a.m., individual animals are audible; quacking ducks, at 2 a.m. possibly frogs and at 3 a.m. again a kind of knocking noise and a "pulling", probably from a small animal that seems to be in the immediate vicinity of the microphone. From the motorway, heavy transport in particular is heard during the night, and at one point it sounds like an aeroplane. From 4 o'clock onwards, the first peeping and singing of birds are perceptible. We hear different bird songs at 6 o'clock, at the same time the morning traffic is at its peak. It gets loud at 8 o'clock due to a leaf blower or a similar machine (in summer the lawn is mowed daily, no doubt...) In the course of the morning we hear single persons walking or jogging past, a woman on the phone and a fast tapping (probably a dog) passing close to the microphone, as well as bathing and quacking ducks. The leaf blower also returns at 10 o'clock, and we hear a conversation between two women. As on the other recording, it is mainly wind that can be heard around noon; as well as children playing and voices of adults. At 1 pm the wind makes the reeds dance back and forth and drowns out most

of it. After noon, the leaf blower and other machines - perhaps from a construction site a little further away - are heard again. The soundscape in the afternoon also consists of a family playing (attention at 3 p.m.: here a father scares his child - and us listeners - right next to the microphone), further conversations can be heard, people walking and jogging past. The various voices increase again towards evening, as does the traffic. Let us now look at the diagram, analogous to the first location, which shows the Acoustic Complexity Index of the recordings near the reeds from 26 October 2020, 6 pm, to 27 October 2020, 6 pm.

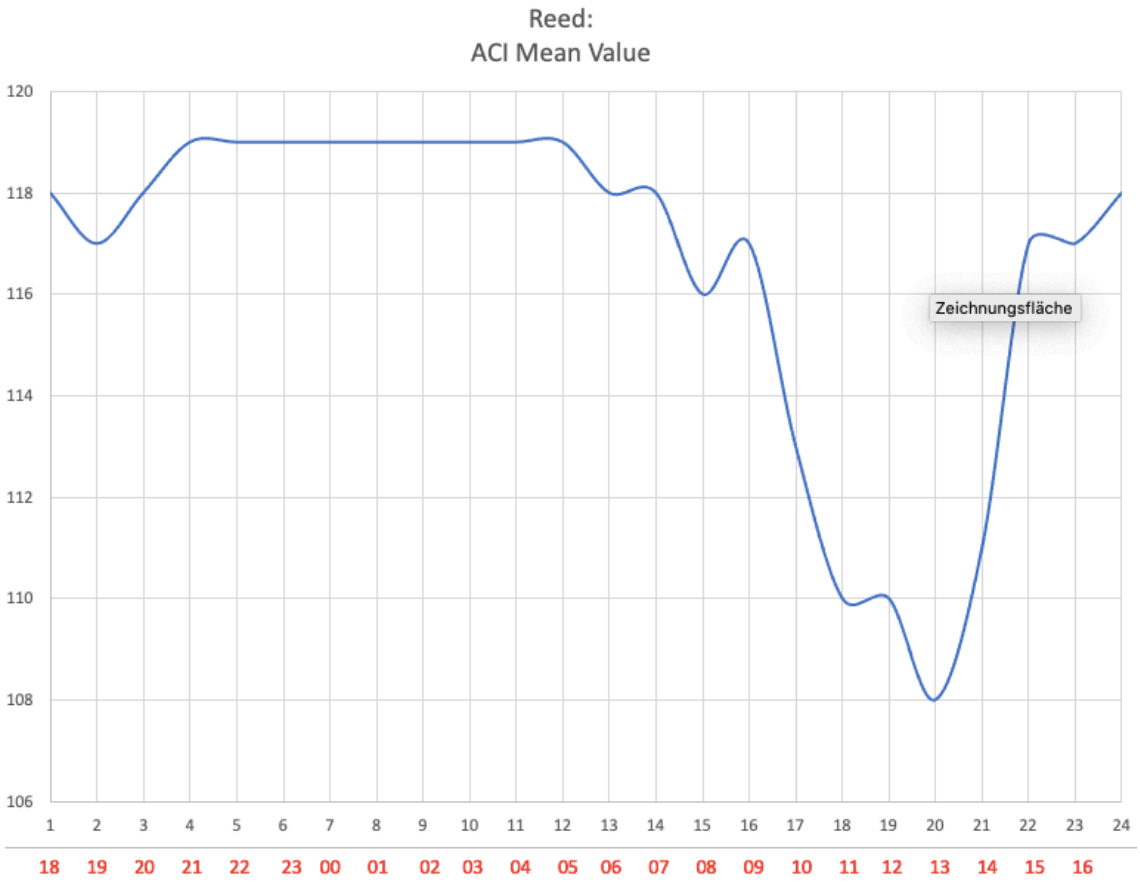

Figure 4: Acoustic Complexity Index, kurz: ACI (y-Achse), der beim Schilf entstandenen Aufnahmen vom 26. Oktober 2020, 18 Uhr, bis 27. Oktober 2020, 18 Uhr (x-Achse), Glattpark bei Zürich.

As can be seen on the diagram, the ACI is higher at night than during the day, similar to the location in the forest, and reaches its lowest point around noon. In my opinion, this low point can be explained by the very present wind, which may have drowned out all other signals arriving on the microphone. Furthermore, it should be noted that traffic is not evaluated as one long-drawn-out signal; rather, all individual motor vehicles seem to leave their own acoustic traces, which is why the variety of different signals is higher at night. At the same time, near sounds of animals are present at night. Dominant sounds during the day - the wind or the leaf blower - seem to drown out diverse other signals, which is why the ACI is lower.

Conclusion

Our recordings have awakened different sensations in me: While the rippling of the rain on the leaves in the forest has something calming for me and creates a feeling of safety, I feel the traffic noise as disturbing and stressful. It has been sufficiently proven that noise has a significant impact on human health, and more and more it can be shown that this also applies to animals: birds increase their pitch when exposed to the low frequencies of traffic, whales are stressed when exposed to heavy shipping traffic - in both cases, animals are no longer able to find each other, fail to reproduce or even locate food.[7] It would be interesting to study the lives of the birds in the recordings and the other animals in Glattpark over a longer period of time. With the help of the wildlife recorders and the soil recordings developed by Maeder and his research team, it was possible for us to listen into other living environments and thus sharpen our sensitivity for habitats of animals, plants and humans, which is also particularly given by the affectivity and immediacy of listening. All the recordings made this semester can be found on the sound map mentioned above. Likewise, if Corona allows, an exhibition will take place in the "Wunderkammer" where one can listen to the individual soundscapes. For me, it was a very interesting insight into the research field of Acoustic Ecology that I was able to gain in this autumn semester. The theoretical basis of this field as well as the experience of listening on site, which Marcus Maeder imparted to us, were revealing - and also worrying, because we directly perceived the extent of noise caused by humans. It seems to be a privilege, at least in cities, to be able to protect oneself sufficiently from noise. And it is disillusioning to realise that all the animals we could observe acoustically - ducks, birds, mice, frogs and also the beaver that lives right next to the SRF tower - are exposed to this noise one-to-one and continuously.

[7] ZEIT WISSEN, *Wale und Vögel nutzen die Corona-Stille,* 17. Mai 2020.