Strategy Paper for
Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forest and Inland Water by Acidifying Species and Related Chemical Substances

Drafted by the Task Force on Soil and Vegetation Monitoring of the EANET and adopted by the Scientific Advisory Committee of the EANET at its 14th Session.

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I. Introduction

1. *The Strategy Paper for Future Direction of Soil, Vegetation and related Ecosystems Monitoring of EANET (2009-2014)* was adopted by the Scientific Advisory Committee at its 8th Session (SAC8) in November 2008 in Hanoi, Vietnam. This is the second *Strategy Paper*, which was updated based on the first *Strategy Paper* developed in 2002. The Task Force on Soil and Vegetation Monitoring of EANET has been promoting activities in line with the *Strategy Papers*, and the Network Center for EANET (NC) has been supporting their activities as the secretariat of the Task Force.

2. The previous *Strategy Paper (2009-2014)* mostly covers important issues on ecological impacts of acid deposition. Many of the activities described in the *Strategy Paper (2009-2014)* have already been implemented or well progressed as milestones for the period, although a few activities may need continuous efforts for implementation. Moreover, ecosystems in the East Asian region are faced with new environmental subjects, such as high concentrations of ozone and particulate matters. Therefore, based on the review of the activities in the previous period, the *Strategy Paper for Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forest and Inland Water by Acidifying Species and Related Chemical Substances* is updated with new milestones for the coming years in the Annex.

3. The updated Strategy Paper directly contributes to the "activity No. (5) *Development/update of strategy paper for guidance on future direction of EANET monitoring, as necessary"* in the *Medium Term Plan (MTP) for the EANET (2011-2015)*.

II. Objectives of soil and vegetation monitoring of EANET

II-1. Initial objectives

4. The initial objectives, "establishment of baseline data" and "early detection of possible impacts" described in the *Guidelines for Acid Deposition Monitoring in East Asia (2000)* and *Technical Manual for Soil and Vegetation Monitoring in East Asia (2nd ISAG, 2000)* can be interpreted as follows.

5. Establishment of baseline data is to describe the present status on plants and terrestrial ecosystems by the basic survey, which was described in chapter 2 of the

Technical Manual. As the baseline data, the following data should be accumulated:

- Chemical properties of soil
- Growth of trees (by description of trees)
- Species composition of understory vegetation

The basic survey should consider climatic zones in the participating countries.

6. Early detection of possible impacts requires establishing the methodologies for detecting decline symptoms on plants in the early stage. To avoid serious damage on plants and terrestrial ecosystem and enable recovery from the problem, the symptoms should be detected in the early stage. In the East Asian region, information on forest decline, plant sensitivities, and their implication with air pollution have not been sufficiently accumulated.

II-2. The long-term objective

7. The long-term objective is "To assess impact of acid deposition on terrestrial ecosystem in a comprehensive and systematic manner through development and maintenance of a good quality database".

8. The long-term objective of soil and vegetation monitoring can be achieved by evaluating spatially and temporally the impacts of acid deposition on terrestrial ecosystem in the East Asian region with understanding the processes (mechanisms) in the ecosystems that are related to acid deposition.

9. For quantitative evaluation of acid deposition impacts, as the first step, the present status of ecosystem should be described by input-output budget analysis and ecosystem modeling in the respective monitoring sites (e.g. catchment areas). Taking account of the above budget analysis and also the present status of soil and vegetation by the basic survey, spatial and temporal evaluation should be promoted by appropriate methods for up scaling of monitoring data.

III. Issues to be implemented to achieve the objectives

III-1. Issues for the initial objectives

III-1-1. Issues for establishment of baseline data

Promotion of continuous monitoring:

10. Accumulation of the data on soil and forest vegetation is the first step for establishment of the baseline data, and the monitoring in the current sites should be carried out continuously at least every 3-5 years interval for soil chemical properties and general description of the forest. Protection/conservation of the monitoring site is important so that long-term data could be accumulated over several decades.

11. Financial and human resources in the respective countries are essential for continuous monitoring. Countries should make an effort to source funds from both national and international organizations. Networking and capacity building of relevant experts should also be promoted to accumulate human resources at both national and regional levels.

Improvement of monitoring system:

12. The number and location of monitoring sites should be reviewed considering climatic zones and the concept of the multi-stage sampling. Monitoring sites should be established systematically even though the numerous monitoring sites could not be established on small grids.

13. The East Asian region is a latitudinally wide area and consists of varied climatic zones. It can be recommended that one area at least should be selected for representative climatic zones in the respective countries. For each area, two types of soil are selected if possible, and plots and subplots are established according to the multi-stage sampling system on soil monitoring.

14. Support by experts on soil and forest vegetation is essential for the monitoring, and such experts should be involved continuously. In most participating countries of EANET, one expert may not be able to complete all work involved in soil, forest vegetation and ecosystems monitoring, and therefore needs cooperation with other experts. The continuous involvement of these experts in the monitoring activities, and establishment of an appropriate system for regular reporting to a national committee involving relevant agencies involved in EANET activities should be considered.

III-1-2. Issues for early detection of possible impacts

15. The Sub-Manual on Forest Vegetation Monitoring in EANET was endorsed by SAC at its 6th Session in 2006. The Sub-Manual proposed modified methods on observation of tree decline and some additional methodologies for early detection

of possible impacts. Observation of tree decline should be conducted at least once a year according to the Sub-Manual. The methodologies described in the Sub-Manual should be utilized to collect the information on possible impacts.

General information of tree decline symptoms in the participating countries:

16. Prior to discussion of air pollution/acid deposition impacts, general information of tree decline symptoms should be accumulated; where, from when, which tree species, how decline, what cause, etc. Since impacts of air pollution and acid deposition may appear in combination with other factors, such as meteorological events and insect/fungus infections, the information should be obtained widely. Literature surveys for scientific publications should be adopted to collect reliable information.

Ozone concentration in agricultural and forest areas and its effects:

17. High concentrations of ozone have become one of the hot topics in the East Asian region due to increase in concentrations of its precursors, such as NO_X. Effects of ozone on vegetation including agricultural crops should be discussed with those of acid substances, since ozone formation in the troposphere is closely related to other air pollutants. To evaluate effects of acid substances precisely, effects of ozone on vegetation should also be considered.

18. The data of ozone concentration in forest area is very limited due to accessibility and lack of power supply in the East Asian countries. Similar situation exists in agricultural area where no power supply is available. Ozone concentration in those areas should be measured/estimated by utilizing various methods. Ozone concentrations could be measured in forest area by using less-expensive methods, such as passive samplers, since diurnal variation may relatively be limited in forest/mountainous area. However, hourly data is necessary to calculate indices of ozone concentrations, such as AOT40 and SUM06[1]. In the case that electrical supply is available near those areas, the automatic ozone monitor should be installed. Moreover, numerical modeling of ozone concentrations may be useful to discuss the spatial distribution and the regional risk on ecosystems.

19. Visible ozone injury should be assessed by field observation or microscopic observation as a field evidence of ozone effects. ICP Forests and ICP Vegetation in

[1] AOT40, Accumulated dose Over a Threshold of 40 ppb; SUM06, a cumulative index of ozone concentrations over a specified threshold (0.06 ppm).

Europe have accumulated a lot of information on the visible injury. Referring the knowledge in Europe, information of the visible injury should be accumulated in the EANET region. A case study or trial campaign for measurement of ozone concentrations in forest area and assessment of visible ozone injury should be promoted. The areas where tree decline symptoms were reported may be likely candidates for the case study.

20. Further steps for assessment of ozone effects should be considered taking progress in other regions such as Europe and US into account. Effects on agricultural crops should also be discussed in near future. Moreover, critical levels using AOT40 or POD_Y[2] should be discussed with relevant EANET bodies, such as Task Force on Monitoring for Dry Deposition.

Potential effects of particulate matters on ecosystems

21. Dry deposition of particulate matters is an important deposition process of sulfur and nitrogen, e.g. $(NH_4)_2SO_4$. In terms of acidification and eutrophication also, particulate matters should be taken into consideration. Moreover, dry deposition of particulate matters into forest area is a removal process of those from atmosphere, which may be considered as one of ecosystem services of forest. The information on concentration/flux of particulate matters in forest area, in particular those of fine particles, should be accumulated.

22. It has been reported that occlusion of stomata due to deposited particles may occur resulting in acceleration of water loss from leaf surface, although relatively coarse particles (> several μm) may mainly be related to this mechanism. Effects of fine particles (< 2.5 μm, so-called $PM_{2.5}$) on tree species are still not clear in the region, although both hygroscopic particles such as $(NH_4)_2SO_4$ and other particles such as BC and heavy metals may have the potential. The updated scientific information on laboratory/field studies should carefully be considered.

23. Atmospheric aerosols and regional haze may decrease yields of agricultural crop due to reduction of surface irradiance, while the aerosols may increase the diffuse fraction of solar radiation that enhances photosynthesis. Both negative (by reduction of direct radiation) and positive (by increase of diffuse radiation) effects should be considered to evaluate net effects of radiation changes on crop yields. The updated scientific information should be considered.

[2] POD_Y, Phytotoxic Ozone Dose above a threshold flux of Y nmol m^{-2} PLA s^{-1}, where PLA is projected leaf area.

Compilation of information on early detection:

24. Procedures to collect information on plant sensitivities and dose-response relationship should be discussed. The information on ozone has been accumulated relatively in China and Japan. The dose-effect relationship for the air pollutants in other countries is necessary to discuss possible risks on plants on the regional scale. The information on epiphytic plant species, such as mosses and lichens, should also be collected since they have been used as indicators of air pollution including acid deposition. The Sub-Manual can provide possible methodologies to collect the information on lichens. Practical solutions to utilize such methodologies should be discussed. It should also be discussed to collect basic information on fauna (e.g. forest insects).

III-2. Issues for the long-term objective

Promotion of regular catchment-scale monitoring

25. The case studies have been conducted in several reference catchment areas by the NC in cooperation with some participating countries. Elemental budget and biogeochemical processes have been discussed in the study catchments to evaluate effects of atmospheric deposition in the forest ecosystems. Based on the experience above, the *Guideline for Catchment-scale Monitoring* was developed by the Task Force and endorsed by the Scientific Advisory Committee of EANET at its 10th Session.

26. The regular catchment monitoring has started in Lake Ijira catchment in Japan according to the *Guideline for catchment-scale monitoring*. The Philippines has a plan to start the regular catchment monitoring in La Mesa Watershed. The catchment-scale data may be informative for discussion of atmospheric deposition impacts quantitatively and qualitatively. It is expected that the regular catchment monitoring will be conducted in other countries.

Catchment analysis and simulation modeling on soil and inland water acidification:

27. Based on the elemental budget and biogeochemical process in the study catchments, possible impacts of acid loads resulting from atmospheric deposition should be evaluated. Disturbance of biogeochemical processes due to atmospheric deposition, including “nitrogen saturation”, is also one of issues to be evaluated.

28. Isotope ratio of some elements, such as sulfur, nitrogen/oxygen of NO_3^- and metals, is specific for their sources and/or changes through biological, geochemical or geophysical processes. Isotopic analysis of the elements from rainwater to stream water in a catchment may be informative for discussion of possible sources and biogeochemical processes in the ecosystems. Use of such techniques should also be considered for the catchment analysis.

29. Simulation model on soil and/or inland water acidification should be developed based on the catchment analysis above. Changes in chemical properties in the acidification process should be simulated in the model. Simulation modeling may help us evaluate the current situation of the ecosystems. A common simulation model applicable for the diverse ecosystems in the East Asian region is highly desired. Trends of soil and/or inland water acidification should also be predicted in future.

30. Direct effects of air pollution on plants may also induce hydrological and biogeochemical effects in ecosystems. For example, it was suggested that ozone altered watershed hydrology due to its effects on leaf transpiration and water use of plants. Physiological changes of plants by air pollution may affect microbial community in soil. In the future simulation model, direct effects of acid deposition/air pollution on plants, and their relations to hydrological/ biogeochemical processes should also be taken into account.

31. The quality of inland waters is being measured at several sites under the inland aquatic environment monitoring (IAEM) program of EANET. In the revised *Technical Manual for IAEM - 2010*, importance of rivers/streams and their catchments is highlighted. The manual should be referred for catchment monitoring in addition to the *Guideline*.

Identification of the areas susceptible to acid deposition

32. Areas or regions susceptible to acid deposition should be identified to conduct the monitoring effectively. As one of the activities in line with the previous *Strategy Paper*, a map of watershed sensitivity to acid deposition was developed by the NC in cooperation with the Task Force members, taking acid neutralizing capacity of soil and surface geology into consideration. The initial goal of the activity may be accomplished.

33. However, spatial distribution of atmospheric depositions/air pollution should also be taken into account to identify actual acidification risk in the region. As a trial

harmonized with this subject, one of the EANET countries developed the risk maps on acidification of soil and watershed and the maps of estimated growth reduction by ozone for representative species in their country. In the case of ozone, sensitivity of each tree species was also taken into consideration. In the trial above, outputs from numerical models on atmospheric depositions and ozone concentration were utilized to estimate the risks.

34. Possibility of utilizing numerical models for the spatial distribution should be considered to estimate actual risks at the national levels as well as regional levels. Moreover, spatial datasets on plant growth, such as NPP (net primary production) have recently been available for discussion on climate change. Such datasets may also be informative for discussion on possible risks on nitrogen deposition, since the growth rate must be related to nitrogen uptake in plants.

Up-scaling of the monitoring data and spatial evaluation

35. For spatial evaluation towards the long-term objective, up scaling of the monitoring data should be discussed as the next step. Use of the following methodologies should be discussed.

36. Based on the data in the basic survey and the catchment analysis, the condition of the region should be estimated by the appropriate spatial modeling, and then described on a map of the region. Regional data on atmospheric deposition may also be required for the evaluation.

37. Regional assessment of possible impacts on ecosystems requires spatial data on atmospheric deposition. Emission inventory and numerical model on transport and chemical processes in the atmosphere are essential for this work. Further steps should be discussed in the EANET community.

38. Remote sensing technology may be helpful to describe the present condition on forest health decline based on the data from the basic survey. The Sub-Manual can provide possible methodologies to utilize remote sensing technology. Satellite image analysis is one of the potential tools to detect changes in tree conditions, such as phonology, vitality of trees, etc. In particular for the susceptible areas to acid deposition/air pollution, which were identified by the previous work in the Task Force, applicability of the technique should be considered. Use of the existing datasets by the remote sensing technology should also be considered. Practical solutions to utilize such methodologies should be discussed in coming years.

IV. Collaboration with relevant networks/organizations

39. The progress of other initiatives in the Asian region related to air pollution/acid deposition may be useful to EANET soil and vegetation monitoring such as Long-range Transboundary Air Pollution in Northeast Asia (LTP) Project, Male Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia, etc. As for LTP Project, an expert meeting is held annually to share the information on the monitoring and modeling activities of the countries concerned. As for the Male Declaration, monitoring activities based on the action plan and establishment of the databases are promoted in each country.

40. In Europe and the North America, much experience has been accumulated. In particular, the Working Group on Effects (WGE) and its International Co-operative Programmes (e.g. ICP Forests, ICP Vegetation, ICP Waters, ICP Integrated Monitoring, etc.) under the CLRTAP (Convention on Long-range Transboundary Air Pollution) in Europe can provide much useful information for the East Asian activities, including its existing monitoring manual for UNECE region.

41. In the research field, the International Union of Forest Research Organization (IUFRO) and International Long-Term Ecological Research Network (ILTER) may have the latest scientific information on forest ecosystems. As for IUFRO, Unit 7.01.00, "Impacts of air pollution and climate change on forest ecosystems" may have relevant information. As for ILTER, collaboration with their national networks, such as Japan LTER network (JaLTER) and Philippines LTER network, can also be considered.

42. Collaboration with these relevant networks/organizations should be promoted for future development of the EANET activities.

V. Overall strategy

43. The overall strategy to achieve the initial and long-term objectives described above can be described as shown in Figure 1.

44. The initial objective is to describe the present status on soil and vegetation in the East Asian region, and it can also be one of steps toward the long-term objective.

45. For the long-term objective, another approach should also be promoted, especially

for description of present status on ecosystem. To achieve these steps, some issues, such as promotion of catchment analysis and modeling, should be implemented.

46. Then, up scaling of these data should be discussed for spatial evaluation of impacts of acidifying species and related chemical substances in the East Asian region.

VI. Acknowledgements

47. This Strategy Paper is a product of the scientific discussions of the members of the Task Force on Soil and Vegetation Monitoring who met in Niigata City, Japan on 25-26 June 2014. The current members of the Task Force gratefully recognize the efforts of the members of the previous task force who formulated the earlier versions of the *Strategy Paper*. This Strategy Paper heavily drew ideas from these earlier *Strategy Papers*, including also new ideas. Gratitude is also extended to the staff of the NC who provided guidance during the formulation of the *Strategy Paper* and the staff of ACAP for making the necessary arrangements for the meeting where this *Strategy Paper* was formed. The Secretariat of the Task Force is most certainly appreciated for their time and efforts which certainly made the task of the Task Force a pleasant one.

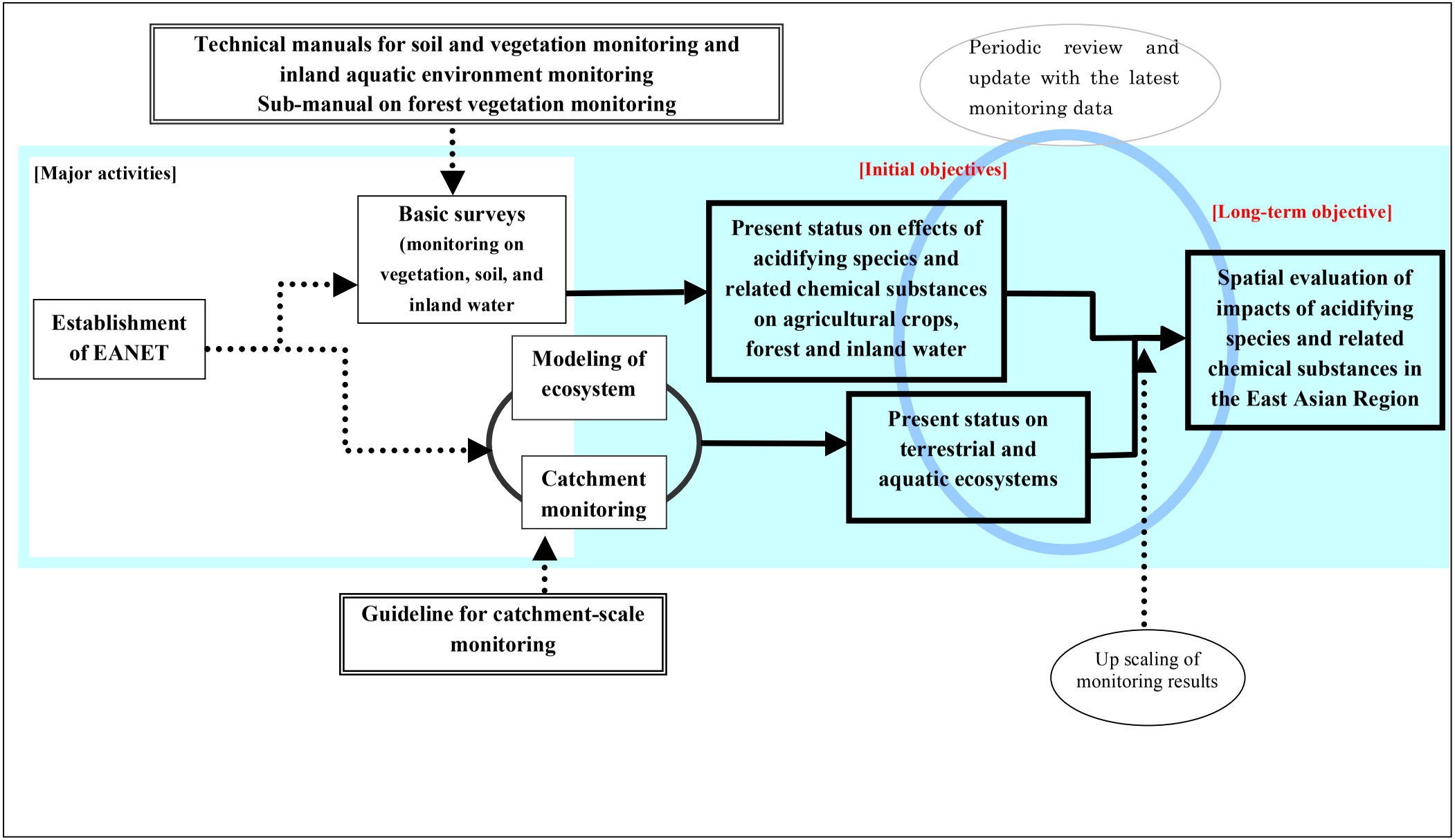

Figure 1. Overall strategy for Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forest and Inland Water by Acidifying Species and Related Chemical Substances

Annex

Specific activities for the coming years, from 2015 to 2020

1. For the coming six years, the following nine activities were identified as the specific works for the period. The activities are expected to be implemented by forming sub-groups.

i. Promotion of continuous monitoring of existing sites

2. Continuous efforts should be made for the long-term monitoring of existing sites in each country. Measurement of soil chemical properties and general description of the forest should be conducted periodically at least every 3 – 5 years. In particular, observation of tree decline should be conducted at least once a year according to the Sub-Manual. Measurement of inland water chemical properties should be conducted four times a year in the case of Lake and 12 times (monthly) a year or 6 times at least in the case of rivers. The Task Force and the NC will make efforts to support the countries on technical aspects.

ii. Improvement of monitoring system

3. Continuous efforts including air pollution effects on agricultural crops should be made for improvement of the monitoring system in each country. The number and locations of the monitoring sites should be reviewed taking the climatic zones into account. The Task Force and the NC will make efforts to support the countries on technical aspects.

4. The information on the area susceptible to acid deposition/air pollution should also be utilized to establish the monitoring system effectively.

iii. Promotion of capacity building activities

5. Capacity building of fieldwork/analytical staff is also essential for continuous monitoring. Continuous efforts should be made to promote the capacity building activities. Technical workshops on ecological impacts may be a good opportunity to share the information. Utilization of PhD programs or fellowship programs may also be effective to improve their research abilities.

iv. Identification of the areas susceptible to acid deposition

6. The sensitivity maps of the region will be updated as appropriate based on literatures, GIS data including geological/soil maps, and spatial datasets such as vegetation information. Preparation of several kinds of maps may be considered for soil sensitivity to acidification, watershed sensitivity to acidification, ecosystem

sensitivity to nitrogen, plant sensitivity to ozone, etc.: in 2015 - 2016

7. The data on soil, forest vegetation and inland water by the regular EANET basic surveys will be compared with the maps above: in 2015 - 2016

8. The maps may be included in the *Third Periodic Report on the State of Acid Deposition (PRSAD3)*: in 2015/2016

9. Many of simulation results by numerical models have been published for air concentrations of ozone and particulate matters as well as atmospheric depositions of sulfur and nitrogen in international journals. It is expected that the sensitivity maps will be overwrapped with the already-published simulation results to identify actual risks in the region. This should be tried at the national levels as well as the regional levels. Part of the assessment may also be included in *PRSAD3*, if necessary: in 2015-

v. Regional review of tree decline symptoms

10. Prior to discussion of air pollution/acid deposition impacts, general information of "tree decline symptoms" should be accumulated. Literature surveys for scientific publications should be adopted to collect reliable information.

11. All the Task Force members are expected to review the relevant literatures written in native languages in local scientific journals as well as those written in English in international journals. If necessary, relationships between the decline symptoms and air pollutants such as ozone will also be discussed in the review. The draft reviews from the Task Force members will be compiled and summarized into a regional review of tree decline symptoms: in 2015-2016

12. The regional review of tree decline symptoms is expected to be included in *PRSAD3*: in 2015/2016

13. The Task Force members will also make a effort to publish the regional review or part of the review in an international journal as a scientific review: in 2015/2016

vi. Trial campaign for ozone effects in forest area and agricultural field

14. The knowledge on visible ozone injury in Europe will be shared in the region. Applicability of the technique to the EANET region will be discussed accumulating the actual data on the visible injury by field observation. The Task Force members will make efforts to accumulate the field data/information on visible ozone injury at the national levels as well as the regional level utilizing various opportunities: in 2015-2017

15. Based on the regional review, the data/information on the visible ozone injury, a project plan of the trial campaign for ozone effects in forest area will be developed. Simultaneously, it is expected that external grants from competitive research funds will be obtained to implement the plan: in 2016-2017

16. The trial campaign is expected to be conducted at least in three or four countries: in 2017-2018

vii. *Promotion of catchment analysis and simulation modeling on soil and inland water*

17. Catchment analysis in existing study sites is expected to be promoted in the case study catchments utilizing competitive research grants in cooperation with relevant organizations/agencies in the EANET participating countries.

18. The isotopic analysis is applied in the study sites to clarify sulfur dynamics in the forest ecosystems. The similar approach will be promoted at the national levels as well as the regional levels: in 2014-2016

19. Part of the outcomes above is expected to be included in *PRSAD3* as one of research outcomes in EANET.

20. Simulation modeling on soil and inland water is also expected to be promoted in the case study catchments utilizing competitive research grants. The knowledge on biogeochemical processes obtained from the isotopic analysis above may be informative for improvement of simulation modeling on soil and inland water: in 2015/2016 or later.

21. Efforts should be made to obtain competitive research grants for further promotion of the catchment analysis and simulation modeling on soil and inland water.

viii. *Accumulation of the information on flux of particulate matters in forest area and its potential effects*

22. The information on concentration/flux of particulate matters in forest area, in particular those of fine particles, will be accumulated. The flux into forest canopy and/or deposited amounts on plant bodies such as leaves and branches will be estimated by field observation, if external grants are available. Contribution of particulate matters to acidification/eutrophication and/or a function of forest canopy for removal process of particulate matters from atmosphere will be discussed by securing research grants.

23. Direct effects of particulate matters on plants by their depositions as well as alternation of sunlight will also be discussed taking the latest scientific knowledge into consideration.

ix. *Evaluation of the ecological monitoring data for the Third Periodic Report on the State of Acid Deposition in East Asia (PRSAD3)*

24. The regional monitoring data on soil, vegetation, and inland water should be evaluated by the members of the Task Force as their contribution to the next periodic report. Prior to the regional assessment, the evaluation of the data on the national levels should be promoted. Some of the activities above by the Task Force may contribute to *PRSAD3*. Small ad-hoc group(s) should be formed if necessary. Practical collaboration with national centers is essential to draw clear pictures on ecological impacts in the region: in 2015 - 2016

Appendix

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