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PM 5/10 (1) Guidelines on the design and implementation of a buffer zone

Scope: This Standard provides general guidance on the use of buffer zones to minimize the probability of spread of a pest into or out of delimited areas. It is intended to be used by risk assessors and risk managers when they are conducting pest risk analysis or designing phytosanitary measures, including for contingency plans.

Specific approval: This Standard was first approved on 2021–09.

Authors and contributors are given in the Acknowledgements section.

Definitions: Definitions relevant to this Standard are noted in Appendix 1.

1 | INTRODUCTION

The IPPC definition (ISPM 5) of a buffer zone is 'an area surrounding or adjacent to an area officially delimited for phytosanitary purposes in order to minimize the probability of spread of the target pest into or out of the delimited area, and subject to phytosanitary or other control measures, if appropriate.'

There are several International Standards for Phytosanitary Measures (ISPMs) that provide some recommendations on the requirements for a buffer zone. These include ISPM 4 (Pest Free Area), ISPM 10 (Pest Free Production Place), ISPM 22 (Area of Low Pest Prevalence) and ISPM 26 (Pest Free Area for Tephritidae). For details, see Appendix 2.

A buffer zone should be large enough to minimize the probability of the pest reaching the area or place of production to be protected by natural spread. The appropriate size and likely effectiveness of a buffer zone is dependent in particular on the biology of the pest, the size and the density of the pest population, the ease of detection, the types of habitat in the buffer zone and the control measures applied in the buffer zone and in the infested area (see Section 3).

In general, National Plant Protection Organizations (NPPOs) are faced with limited resources for mitigation activities. If the buffer zone is too small in relation to the pest's dispersal capacity, it will spread out of the buffer zone and efforts to eradicate or contain it will be wasted. Conversely, if the buffer zone is too large in relation to the pest's dispersal capacity, unnecessary effort and resources may be used. It is also important that required measures are feasible and are implemented correctly. This may be difficult if the buffer zone is very large. The size of the buffer zone should be technically justified and be based on a cost-benefit approach. Cost-benefit analysis is discussed in EPPO Standard PM 9/18 *Decision-Support Scheme for prioritizing action during outbreaks*. A protocol for analysing the costs and benefits of phytosanitary measures is also provided by Kehlenbeck et al., (2012).

Decisions on the size of a buffer zone often have to be made in the absence of, or with limited, scientific data. This Standard can be applied by risk assessors and risk managers to enable them to make better judgments regarding the appropriate size of buffer zones and the related phytosanitary measures. The guidelines aim to make the decision-making process transparent and to ensure that a consistent approach is used.

2 | OBJECTIVE OF DELIMITED AREAS INCLUDING BUFFER ZONES

A buffer zone can be implemented as a phytosanitary measure to (a) prevent or suppress dispersal of a pest in an eradication or containment program or (b) prevent the introduction of a pest and help guarantee pest freedom of a specified area/place of production (see Figure 1 and Appendix 2).

Scenario (a) deals with an outbreak area in an eradication/containment program. In this case the aim of the buffer zone is to prevent spread of the pest from the infested area beyond the delimited area.

Scenario (b) deals with the maintenance of a Pest Free Area (PFA), a Pest Free Production Place (PFPP) or a Pest Free Production Site (PFPS). The aim of the buffer zone in this case is to prevent entry of the pest into the buffer zone and to maintain pest freedom of the area/place of production to be protected. The main difference between scenarios (a) and (b) is the source of the pest population that has to be prevented from moving through the buffer zone.

The appropriate size of the buffer zone is likely to differ depending on the objective of the buffer zone (eradication, containment or pest freedom). Guidance on determining

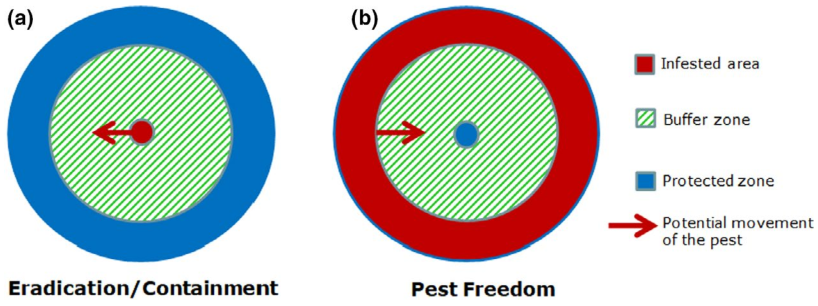

FIGURE 1 Schematic representation of the different zones in scenario (a) and scenario (b)

the appropriate size is given in Section 3. Measures associated with the different objectives of delimited areas (including the buffer zone) are described in Section 4.

3 | GUIDANCE TO DEFINE AN APPROPRIATE SIZE OF THE BUFFER ZONE

3.1 | Factors to consider when evaluating the dispersal rate

The appropriate size of a buffer zone depends on several factors related to the biology of the pest and the local environment. The dispersal behaviour of the pest should always be taken into account when defining the appropriate size of the buffer zone. Factors which should be taken into account when evaluating the dispersal rate of a pest are presented below, as well as the influence of these factors on the size of the buffer zone.

3.1.1 | Factors to take into account when evaluating the dispersal rate

- Biology of the pest

Factor	Influence on the size of the buffer zone
Lifespan of the pest in relation to growing period	The longer the lifespan of the mobile life stages, the longer the time for dispersal and therefore the distance of spread. However, when a pest has multiple (short) generations during a growing period, the size of the buffer zone should also be increased. In the case of an outbreak, if there is evidence that the pest has been present for several years, the size of the buffer zone ('survey area') should match the expected maximum distance that the dispersing generations may have spread.
Rate of reproduction of the pest	When the pest has a high reproduction rate, populations may build up rapidly. Population size affects the likelihood of long-distance dispersal: in the case of a high-density source population, the size of the buffer zone should match the increased likelihood of long-distance dispersal events.
Dispersal behaviour of the pest or its vector	The likelihood of long-distance spread should be considered. Also consider the mode of dispersal (active by flight or passive by wind) and the life stage that disperses (e.g. spores, winged sexual stages, etc.).

3.1.2 | Local factors to be taken into account when making the decision for a specific case

- Local environmental factors

Factor	Influence on the size of the buffer zone
Abundance and distribution (habitat fragmentation/ heterogeneity) of host plants	Depending on the biology of the pest, spread may be enhanced or decreased when the host plants are scattered.
Natural barriers	Natural barriers (e.g. rivers and mountains) may prevent the pest from spreading further, thereby reducing the size of buffer zone required. Rivers can, however, also act as a means of long-distance spread as is the case, for example, with some bacterial pathogens.
Artificial barriers	When host plants are grown under protection (e.g. glass/plastic/netting), this may provide a barrier to the movement of pests, reducing the size of the buffer zone needed.
Local climatic conditions (e.g. windy vs wind-protected site, direction of prevailing wind)	For pests dispersed by wind or air current, buffer zones may have to be adjusted to take into account prevailing winds. If the pest of concern can only survive under protected conditions in the region or country, then the risk of it spreading from that environment may be reduced.

- Other factors

Factor	Influence on the size of the buffer zone
Ease of detection, certainty and ease of defining the infested area	If the pest is difficult to detect, the size of the buffer zone should be increased to take into account the risk of delayed detection. If no reliable inspection or testing methods are available it may not be feasible to establish a buffer zone.

Factor	Influence on the size of the buffer zone
Control measures applied and objective of the buffer zone (eradication, containment or maintenance of pest freedom for areas, place of production or site of production)	See Sections 4.1 and 4.2

It should be noted that a major mode of long-distance dispersal is human assisted (e.g. movement of plants and firewood and hitchhiking). When a literature review is done to estimate the natural dispersal capacity of the pest, it is important that human-assisted movement is excluded to avoid overestimating natural spread. However, to manage the pest, it is important to take into account human-assisted movement and to officially control it, where possible. As human-assisted movement may have already occurred before the discovery of the outbreak, this information is important to design appropriate delimiting surveys to confirm pest distribution.

3.2 | Description of the dispersal behaviour of a pest

Dispersal is the departure, movement and settlement of a pest leading to successful establishment. For arthropods, biological dispersal refers to the spatial movement of individuals from the birth site to the subsequent reproduction/oviposition site (i.e. in one generation). For fungi, dispersal refers to the spatial pattern of successful spore deposition leading to further infection.

The dispersal behaviour of many pests can be described as stratified dispersal, which is the combination of probable short-range dispersal and rare long-range dispersal (Liebhold & Tobin, 2008). This implies that the vast majority of a dispersing population does not disperse far from the outbreak source and that only a few individuals disperse extremely far. Spread through stratified dispersal is typified by fat-tailed dispersal distributions (see Figure 2 for an example of a dispersal curve for a fungus).

3.3 | Estimation of the dispersal

3.3.1 | Literature review and data retrieval

A literature review should be conducted to collate data on the natural dispersal capacity of the pest, and the degree of relevance and reliability of each piece of information evaluated (see Appendix 3, Step 1). The most reliable data are from experiments where the source population is under experimental control, such as mark release recapture studies (e.g. for insects or fungal spores). Flight mill experiments (for review see, for example, Naranjo, 2019) can also provide useful data but are likely to overestimate how far an insect would travel in the field. If no information can be found on the pest of concern, then information on another species which is closely related taxonomically or a species with very similar biology could be used for guidance.

Information on the distance of spread derived from situations where the source of the initial outbreak is not known (e.g. location of the source and year of introduction) should be interpreted with caution. In such situations, when a new outbreak is detected this may not always be due to a spread from the first detected outbreak but to multiple introductions by natural or human-mediated spread. For example, when a new outbreak is discovered far away from a known outbreak, it cannot be assumed that the pest has spread naturally from the known outbreak since it may be due to human-assisted spread (e.g. with plants for planting) or spread from an undiscovered population close to the new outbreak, or a new introduction.

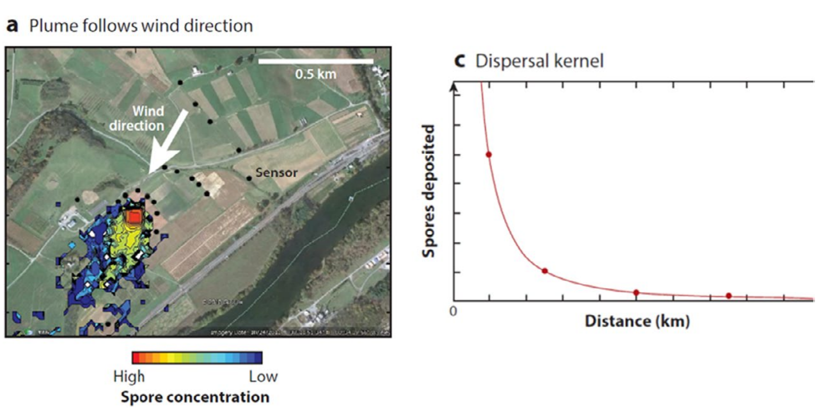

FIGURE 2 Example of distribution of spore deposition from a source point and the estimated dispersal kernel, taken from Schmale and Ross (2015)

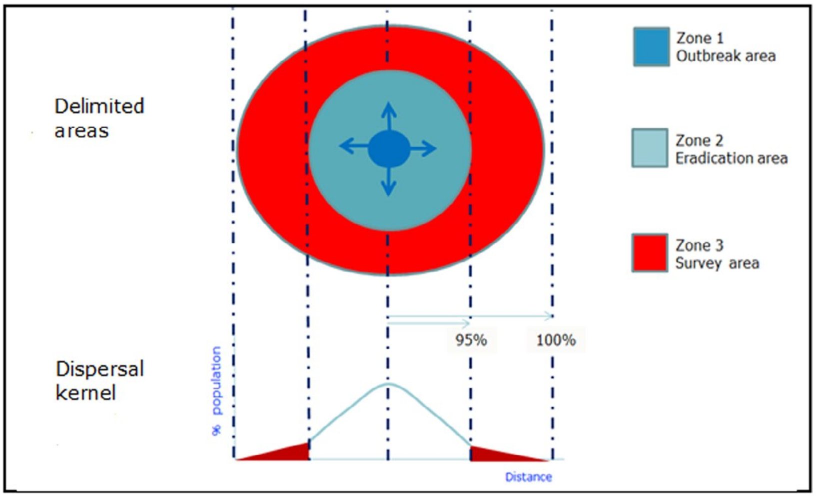

FIGURE 3 Schematic representation of the relationship between dispersal behaviour and the appropriate size of the delimited areas (see Table 1). Note that 95% is an example: the choice of the relevant percentile quantiles should be based on a cost-benefit approach, taking into account in particular the dispersal capacity of the pest, the ease of pest detection and the cost of the measures compared to the potential impact of the pest

3.3.2 | Expert judgement of dispersal behaviour

The dispersal behaviour of a pest is usually described by a dispersal kernel, which is a graphical representation of the statistical distribution of dispersal distances or the density of dispersing individuals at different distances from the source (for review see, for example, Nathan et al., 2012).

If there are appropriate models describing the dispersal behaviour available (for the particular pest species or a similar species) they should be used. The probability of the dispersal distribution can be obtained by statistical analysis of suitable data. However, the absence of suitable data to estimate distributions by statistical analysis is common in plant health risk assessments. In this case, experts can be consulted to estimate the dispersal behaviour based on the available evidence. EFSA (2014, 2018, 2019) provides guidance on how the expert knowledge elicitation (EKE) process can be used to estimate a risk parameter, taking into account the uncertainty of the estimation.

To estimate the dispersal kernel of the pest, an estimation can be made of the important parameters of the dispersal curve (e.g. median and maximum of the dispersal distance). The assessors express their uncertainty of these parameters by expressing the values of the estimated parameters in terms of probability distributions [see section 3.9.3 of EFSA (2018), Guidance on quantitative pest risk assessment]. It should be noted that the elicitation process needs to be led by an experienced EKE facilitator and that experts participating should have received training in the EKE process. A statistician may also be needed to analyse the outcome of the elicitation. The detail of the process is presented in Appendix 3.

Whether a formal EKE process is conducted or not, it is important to record in a short report the evidence and the reasoning of the experts that was considered to estimate the dispersal behaviour and the size of the delimited areas.

4 | GENERAL MEASURES TO BE IMPLEMENTED IN DELIMITED AREAS

The appropriate size of the different delimited areas may vary depending on the measures applied.

4.1 | Objective of the delimited areas

4.1.1 | Eradication

The dispersal kernel of a pest reflects the spatial pattern of the likelihood of pest presence. For insects, the dispersal kernel can be envisaged as the probability distribution of oviposition sites originating from a source population. In Figure 3 the relationship between the dispersal kernel and the size of different delimited areas is graphically summarized. Assuming a homogeneous habitat, the highest density of deposited eggs is expected in the (assumed) epicentre of the outbreak (zone 1 in Figure 3).

The aim of eradication is to remove all possible pest stages (e.g. eggs/larvae/adults for insects) present in the area surrounding the outbreak area (zone 2, Eradication area in Figure 3). The risk manager decides what the acceptable risk is of missing satellite populations (outside zone 2), which will not be affected by the measures (e.g. insecticide treatment or host plant removal). A decision could be that the stringent eradication measures in zone 2 are targeted at 95% of the dispersed pest population. In this case, the size of zone 2 should match the 95th percentile of the dispersal kernel of the pest (see Figure 3). This implies that 5% of the pest population may have escaped the eradication measures. To detect these possible satellite populations a detection survey is carried out in the area surrounding zone 2. The size of this survey area should match the maximum expected dispersal capacity of the pest (zone 3 in Figure 3). If the dispersal kernel has a very long tail the distance of the 99% percentile of the dispersal kernel of the pest may be chosen.

In the case of confirmation of pest presence in zones 2 or 3, the positioning of the delimited areas should be adjusted accordingly (see, for example, EPPO Standard PM 9/1 *Bursaphelenchus xylophilus and its vectors: procedures for official control*). The strategy may also be changed from eradication to containment, taking into account the costs and benefits of enlarging the buffer zone.

4.1.2 | Containment

If the aim is the containment of a pest in an isolated area, the same procedure to define the size of the different zones can be applied as described above. The main difference is that in the containment strategy there are areas where the pest density may be higher compared to the eradication strategy. Therefore, long-distance dispersal events may occur more frequently compared to the eradication strategy. The increased frequency of long-distance dispersal events may increase the probability of missing satellite populations. As a consequence, the size of zones 2 and 3 will usually be larger in the containment strategy than in the eradication strategy to keep the same level of acceptable risk.

4.1.3 | Maintenance of pest freedom for an area, a place of production or a site of production

The aim is to prevent introduction to or the re-infestation of a PFA, PFPP or PFPS. Where there are no other means of preventing pest movement to the PFA, PFPP or PFPS, a buffer zone should be established. Measures that may be applied for the buffer zone include removal of host plants, vector control, precautionary treatments with plant protection products (e.g. insecticides or fungicides), restrictions on movement of host material into the buffer zone, and surveillance to monitor the effectiveness of the buffer zone (e.g. trapping network). As abundance of the pest in the infested area may be high, the size of the buffer zone should ideally be at least the maximum dispersal capacity of the pest within an appropriate period (e.g. one growing season).

4.2 | Associated measures

In Table 1 an overview is given of typical phytosanitary measures applied in the different delimited areas (see also EPPO PM 9/18 (1) *Decision-Support Scheme for prioritizing action during outbreaks*).

4.2.1 | Surveillance

Surveillance is relevant to all the above situations. The availability of sampling strategies which can detect low levels of the target pest is one of the most critical factors in delimiting the infested area and an effective buffer zone. For example, effective and cost-effective traps and lures (i.e. species-specific pheromones) may facilitate early detection. Several levels of intensity of surveys may be set depending on the distance between the pest-free area and the infested plants or the infested area (see examples in Appendix 2, part II, in EPPO Standards in series PM 9, or in EFSA pest survey cards).

Delimiting surveys are needed to establish the actual size of the outbreak area. When a new outbreak is discovered and it is unclear how long the outbreak has been present, a decision has to be made as to how large the delimiting survey should be to establish the spatial extent of the outbreak. If the outbreak is assumed to have been present for several generations/years, the maximum natural spread distance from the assumed source population has to be estimated. Information on the dispersal behaviour of the pest (i.e. dispersal distance in one generation) can be used to calculate the assumed maximum natural spread over the relevant period of time.

Typical surveillance measures are as follows:

- Inspections by trained personnel
- Traps that are periodically inspected
- Sampling and testing of host plants.

4.2.2 | Uncertainty

If there is high uncertainty on the delimitation of the infested area, a more precautionary approach may need to be applied (e.g. it may be decided to remove all host plants instead of only infested plants).

For some pests (e.g. pests that have very severe economic, environmental or social impact and a high reproductive potential, including the ability to create a new population from one or a few individuals), it may be justified to follow a ‘zero-tolerance’ approach and thus to apply measures to the whole pest population. In this case, depending on the result of a cost-benefit analysis and the feasibility of the application of the measures, the risk managers should choose the best option between:

TABLE 1 Description of different types of delimited areas and related phytosanitary measures

Delimited areas	Biological relevance	Typical phytosanitary measures
Eradication		
1. Outbreak area (infested plants) (zone 1 in Figure 3) Other typical names in literature or regulations: focus zone, eradication zone[a]	Source population/outbreak area (e.g. oviposition sites) Uncertainty about pest presence is very low	• Removal and destruction of infested plants • Appropriate treatment • Measures to prevent human-assisted spread (e.g. restriction on movement of host plants)
2. Eradication area: zone in the immediate vicinity of the outbreak area (zone 2 in Figure 3) Other typical names in literature or regulations: infested area, infested zone, clear cut zone, intensive survey area	Likely/possible pest populations reached by short-range dispersal (e.g. oviposition sites) Uncertainty on pest presence is low to medium	• Removal of all host plants Inspection/testing of all host plants • Habitat manipulation (e.g. crop rotation) • Measures to prevent human-assisted spread (e.g. restriction on movement of host plants for planting) • Pesticide programmes • Disinfection of tools, equipment, machinery, vehicles, warehouses and sheds • SurveillanceIn the case of a finding: adaptation/new delimited area
3. Survey area: zone surrounding areas 1 or 2 as defined above (zone 3 in Figure 3) Other typical names in literature or regulations: surveillance area, buffer zone, safety zone	Pest populations due to (rare) successful long-range dispersal Uncertainty on pest presence is high	• Surveillance (trapping/sampling) • Public awareness • In the case of a finding: adaptation/new delimited area
Containment		
1. Containment area	Area where the pest is established Uncertainty on pest presence is very low	• Prevention of movement of host material out of the area • Removal and destruction of some infested plants • Treatments to reduce pest populations (e.g. sterile insect technique)
2. Zone surrounding zone 1 (optional)	Likely/possible pest populations reached by short-range dispersal (e.g. oviposition sites) Uncertainty on pest presence is low to medium	• Prevention of movement of host material out of the area • Intensive surveillance • Testing of symptomatic host plants • Removal and destruction of all infested plants • Habitat manipulation (e.g. crop rotation) • Pesticide programmes • Disinfection of tools, equipment, machinery, vehicles, warehouses and shedsIn the case of a finding: adaptation/new delimited area
3. Zone surrounding zones 1 and 2 as defined above Typical names in literature or regulation: survey area, buffer zone, safety zone	Pest populations due to (rare) successful long-range dispersal Uncertainty on pest presence is high	• Surveillance (trapping/sampling) • Public awareness • In the case of a finding: adaptation/new delimited area
Pest-free area/place/site		
1. Zone around a pest-free production site, pest-free production place or a pest-free area	Pest populations not able to reach the pest-free area/place/site	• Removal of host plants • Treatments against vector • Precautionary treatments with plant protection products (e.g. insecticides or fungicides) • Restrictions of movement of host material into the buffer zone • Surveillance (trapping/sampling)

[a]'Infested zone' in EU Regulation 2016/2031 covers the outbreak area and the eradication area.

- Applying eradication or containment measures, and if appropriate intensive surveillance measures, to cover the totality (100%) of the pest population
- Applying eradication or containment measures to cover only the vast majority (e.g. 99% or 95%) of the pest population and (less intensive) surveillance measures targeting the remaining (e.g. 1% or 5%) of the pest population.

4.3 | Consequences of a breach

In the event of a detection of the pest in the buffer zone that can be considered to constitute an outbreak, the infested area should be enlarged to include this new outbreak and a new buffer zone should be defined.

In the case of a finding of the pest in the buffer zone for a PFA, a PFPP or a PFPS, the pest-free status of the place of production or production site or the area may be withdrawn or appropriate control measures may be required in the buffer zone (see, for example, ISPM 26).

4.4 | Overview of constraints when establishing a buffer zone and situations when a buffer zone may not be justified

Different types of limitations may apply when establishing a buffer zone with phytosanitary measures.

Technical limitations:

- If the natural dispersal capacity of the pest is very high (e.g. hundreds of kilometres by wind), establishing an effective buffer zone may not be feasible. This may also be the case in situations where hitchhiking is a major pathway and effective measures cannot be applied.
- If the generation time is very short, it may be very difficult to apply measures in time to prevent escape from the delimited area and therefore a buffer zone wider than the expected dispersal distance of the pest per generation will be required.
- If the delimiting surveys show that the pest is already widespread, establishing a buffer zone may not be feasible.

Other limitations:

- Regulatory limitations: the delimitation of the buffer zone may have to take into consideration whether protected species occur in the delimited area that would be adversely affected by the control measures.
- Economic, environmental and social limitations: the host plants grown in the buffer zone might be subjected to stringent measures; possible economic, environmental or social constraints should be identified and assessed.
- When there is evidence that the pest was recently introduced into the area with the plants on which it was found, and it can be established that no spread has occurred, then the delimitation of regulated areas is not needed.

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APPENDIX 1- DEFINITIONS

Dispersal	The intergenerational spatial movement of individuals from their place of emergence to a new location where reproduction takes place.
Dispersal behaviour	The mode and distance of intergenerational movement of individuals from a common source.
Dispersal capacity	Maximum dispersal distance of a pest from place of emergence to location where reproduction takes place.
Dispersal curve	A graphical representation of the distribution of dispersal distance.
Dispersal kernel	The statistical (probability) distribution of dispersal distances travelled by any individual in a population originating from a common source.
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (ISPM 5 definition).
Stratified dispersal	Dispersal incorporating two coincident forms of dispersal: (1) short-distance continuous dispersal and (2) rare dispersal events over long distances.
Quantile	Quantiles are values that divide the range of a probability distribution into contiguous intervals with equal probabilities. Quartiles are the three cut points that will divide a distribution into four equal-size intervals, each with a probability of 25%.
Uncertainty	All types of limitations in available knowledge that affect the range and probability of possible answers to an assessment question. Available knowledge refers here to the knowledge (evidence, data, etc.) available to assessors at the time the assessment is conducted.
Median	The numeric value separating the higher half of a sample, a population or a probability distribution from the lower half. The median is generally used for skewed distributions.
Mean	The mean is determined by adding all the data points in a population and then dividing the total by the number of points.
Mode	The mode of a set of data values is the value that appears most often.

APPENDIX 2- BUFFER ZONE DEFINITION AND IMPLEMENTATION IN INTERNATIONAL STANDARDS FOR PHYTOSANITARY MEASURES (ISPM) AND IN THE EU LEGISLATION (EXTRACTS TAKEN IN NOVEMBER 2020)

I. ISPMs where buffer zones are mentioned

1. ISPM 5: Glossary of phytosanitary terms

'**buffer zone** – An area surrounding or adjacent to an area officially delimited for phytosanitary purposes in order to minimize the probability of spread of the target pest into or out of the delimited area, and subject to phytosanitary or other control measures, if appropriate [ISPM 10, 1999; revised ISPM 22, 2005; CPM, 2007].'

2. ISPM 10: Requirements for the establishment of pest-free places of production and pest-free production sites

Point 1.1: 'The extent of the **buffer zone** and the nature of the phytosanitary measures will depend on the biology of the pest and the intrinsic characteristics of the place of production or production site.'

Point 2.3: 'The extent of the **buffer zone** should be determined by the NPPO, on the basis of the distance over which the pest is likely to spread naturally during the course of the growing season.'

3. ISPM 4: Requirements for the establishment of pest free areas

Point 1.2.2: Phytosanitary measures to maintain freedom.

'Specific measures can be used to prevent the introduction and spread of a pest including:

- regulatory action such as the:
  - listing of a pest on a quarantine pest list
  - specification of import requirements into a country or area
  - restriction of the movement of certain products within areas of a country or countries including **buffer zones**'

4. ISPM 21: Pest risk analysis for regulated non-quarantine pests

Point 4.5.1: Area of production.

'The following options may be applied to the area of production of the plants for planting:

- treatment
- area of low pest prevalence
- area where the pest is absent
- **buffer zones** (e.g. rivers, mountain ranges, urban areas)
- monitoring survey.'

5. ISPM 22: Requirements for the establishment of areas of low pest prevalence

Point 2.1: Determination of an area of low pest prevalence.

'Examples of where an ALPP may be established by an NPPO according to this standard are:

- an area of production where products are intended for export
- an area under an eradication or suppression programme
- an area acting as a **buffer zone** to protect a PFA'

6. ISPM 26: Establishment of pest-free areas for fruit flies (Tephritidae)

Point 2.2.1: **Buffer zone**.

'In areas where geographic isolation is not considered adequate to prevent introduction to or reinfestation of a PFA or where there are no other means of preventing fruit fly movement to the PFA, a **buffer zone** should be established. Factors that should be considered in the establishment and effectiveness of a **buffer zone** include:

- pest suppression techniques which may be used to reduce the fruit fly population, including:
  - use of selective insecticide-bait
  - spraying
  - sterile insect technique
  - male annihilation technique
  - biological control
  - mechanical control, etc.
- host availability, cropping systems, natural vegetation
- climatic conditions
- the geography of the area
- capacity for natural spread through identified pathways
- the ability to implement a system to monitor the effectiveness of **buffer zone** establishment (e.g. trapping network).'

7. ISPM 36: Integrated Measures for Plants for Planting

Appendix 1: Examples of pest management measures to reduce the pest risk of plants for planting at a place of production.

'Isolation from sources of infestation (e.g. **buffer zone** or geographical distance from other host plants, physical isolation using a glasshouse or polytunnel, isolation in time (e.g. growing season) from a source of infestation (temporal isolation)).'

8. Conclusion

Based on the above Standards the buffer zone is used to minimize the probability of spread of a pest into PFA, PFPP or PFPS. In ISPM 26, point 2.2.1, factors that should be considered in the establishment of a buffer zone are listed and are considered in the guidance.

II. Buffer zones in EU Commission implementing decisions

Purpose:

1. To prevent a pest spreading from the 'infested zone': a demarcated area is established, which consists of an '*infested zone*' and a buffer zone (EU Commission Implementing Decisions e.g. for *Anoplophora glabripennis*,[1] *Xylella fastidiosa*,[2] *Bursaphelenchus xylophilus*[3]).

Phytosanitary measures in a buffer zone may be:

- a survey
- the prohibition of movement of specified plants, plant products or other objects
- the removal and disposal of infested plants etc.

In the EU Commission Implementing Decision for *B. xylophilus*, a demarcated area shall consist of a zone in which the pine wood nematode (PWN) was found to be present, hereinafter '*the infested zone*', and of a zone surrounding the '*infested zone*', hereinafter '*the buffer zone*'. The buffer zone shall be of a width of 6–20 km.

Two levels of a buffer zone are in the legal act for *B. xylophilus*:

a. 100–500 m radius around each infested tree (phytosanitary measure: cutting of all susceptible plants, removal of wood, etc.). Conditions to establish a buffer zone:

'When establishing a demarcated area, the Member State concerned shall immediately, in that area, create a zone with a minimum radius of 500 m around each susceptible plant in which PWN has been found to be present, hereinafter 'the clear-cut zone'. The actual radius of that zone shall be determined, for each susceptible plant in which PWN has been found to be present, based on the risk of transmission of PWN by the vector further than 500 m away from that susceptible plant.'

b. 500 m–6 km (up to at least 20 km): different measures (i.e. intensity of a survey) are set up for different distances up to 3000 m from the infested tree and from 3000 m to 6 km (or 20 km).

2. To protect a PFPP from infestation, e.g. Commission Implementing Regulation for *Pseudomonas syringae* pv.

[1]Commission Implementing Decision (EU) 2015/893 of 9 June 2015 as regards measures to prevent the introduction into and the spread within the Union of *Anoplophora glabripennis* (Motschulsky). Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015D0893.

[2]Commission Implementing Regulation (EU) 2020/1201 of 14 August 2020 as regards measures to prevent the introduction into and the spread within the Union of *Xylella fastidiosa* (Wells et al.) (consolidated version of August 2020). Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02020R1201-20200817.

[3]Commission Implementing Decision of 26 September 2012 on emergency measures to prevent the spread within the Union of *Bursaphelenchus xylophilus* (Steiner et Buhrer) Nickle et al. (the pine wood nematode) (consolidated version of April 2018). Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02012D0535-20180423.

actinidiae.[4] The 'surrounding zone' of a PFPP consists of two parts:

a. 500 m radius around the PFPP where more stringent measures are applied (twice a year inspection with no infected plants found, or absence of kiwi plants, or regular testing of each kiwi plant).
b. 500 m–4500 m with requirements for a survey and eradication measures (or absence of kiwi plants, or sampling scheme).

3. Conclusion

From the EU legislation it is possible to conclude that:

1. buffer zones are established to prevent spreading of a pest from an '*infested zone*' to other parts of a territory, as well as for establishment and maintenance of a pest free place of production (to prevent a pest from entering a PFPP).
2. In both cases mentioned above, there is a possibility to establish different sizes of buffer zones (based on the distance from the '*infested zone*') depending on the capacity of pest to spread.

APPENDIX 3- EXPERT KNOWLEDGE ELICITATION OF DISPERSAL BEHAVIOUR IN A WORKING GROUP

It should be noted that the elicitation process needs to be led by an experienced expert knowledge elicitation (EKE) facilitator and that experts participating should have been trained in the EKE process. A statistician may also be needed to analyse the outcome of the elicitation.

This section provides guidance on how to estimate the dispersal rate of pest populations from a source point (e.g. outbreak) by expert judgement in the framework of an expert working group (EWG). It should be noted that the expert elicitation should be done for a well-defined scenario.

The dispersal behaviour is usually described with a dispersal kernel (i.e. dispersal curve). To estimate the dispersal kernel of the pest, an estimation can be made of the most important parameters of the distribution of dispersal distances (i.e. dispersal kernel), such as the median (50%), 25%, 75%, 95% and maximum (see Figure 4). In consultation with the risk managers, it may be decided that it is not necessary to estimate the full dispersal kernel, but only the parameters that are relevant for decision making, such as the estimated local dispersal rate (e.g. median of the distribution curve) and/or the estimated long range dispersal' (e.g. the 95th percentile of the distribution curve).

In summary the following steps are followed:

- Step 1: Review and summarize all the available scientific evidence on the natural dispersal of the pest (i.e. human-assisted dispersal excluded).
- Step 2: Define a general scenario for which the dispersal will be estimated.
- Step 3: Decide (e.g. with the risk managers) which parameter(s) should be estimated.
- Step 4: Follow an EKE process to estimate each parameter and the associated uncertainties. Ideally a working group should be set up with a facilitator experienced in expert elicitation and experts on the biology of the pest.
- Step 5 (optional): Use the estimated values for the different parameters of the dispersal kernel to elicit a dispersal curve that best represents the collective expert judgement of the dispersal behaviour of the pest under consideration. This step should be performed with the help of a statistician.
- Step 6: Produce a report listing the evidence used and the reasoning of the expert working group for the evaluation of the parameters and communicate the output to the risk managers.

Difference between median, mean and mode

Mean and median are statistical terms that have a somewhat similar role in terms of understanding the central tendency of a set of statistical scores. While the mean has traditionally been a popular measure of a mid-point in a sample, it has the disadvantage of being much affected by any single value being very high or very low compared to the rest of the sample. This is why a median is sometimes taken as a better measure of a mid-point.

The mean is not a robust tool since it is largely influenced by outliers. The median is described as the numeric value separating the higher half of a sample, a population or a probability distribution from the lower half. The median is generally used to locate the mid-point in a skewed distribution.

The median is the number found at the exact middle of the set of values. A median can be determined by listing all numbers in ascending order and then locating the number in the centre of that distribution.

The mode of a set of data values is the value that appears most often. Like the statistical mean and median, the mode is a way of expressing, in a (usually) single number, important information about a random variable or a population. In a normal distribution, the mode is the same as the mean and median, whereas in highly skewed distributions they may be very different.

Step 1: Review and summarize all the available scientific evidence on the natural dispersal of the pest (i.e. human-assisted dispersal excluded)

Available information may include quantitative data that are of limited quality or unsuitable for statistical analysis, and/or qualitative and anecdotal information or expert experience and reasoning. The degree of relevance

[4]Commission Implementing Regulation (EU) 2020/885 of 26 June 2020 as regards measures to prevent the introduction into and the spread within the Union of *Pseudomonas syringae* pv. *actinidiae* Takikawa, Serizawa, Ichikawa, Tsuyumu & Goto. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R0885.

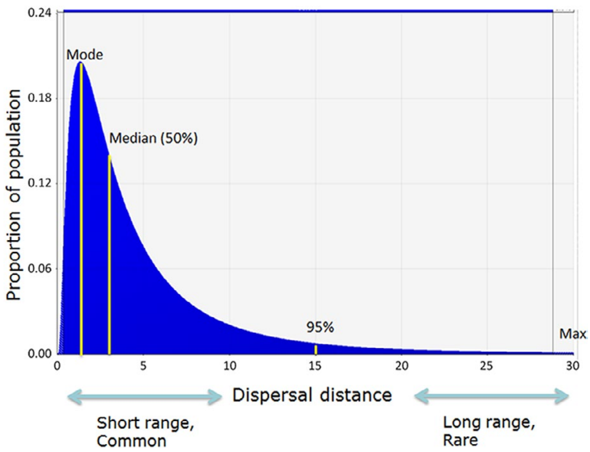

FIGURE 4 Example of a 'fat tail' distribution and parameters describing the dispersal curve [Colour figure can be viewed at wileyonlinelibrary.com]

and reliability of each piece of information used should be taken into account and recorded when using it to inform any judgements. It is important to estimate and document evidence of expected short-range dispersal (i.e. majority of population) and long-range dispersal (i.e. rare events) and to list all relevant uncertainties. When only limited data is available or when data from other species are extrapolated, this should be clearly stated and documented.

It should be noted that data should be interpreted with caution. For example:

- When the source of the dispersed pest population is not specified in the study (e.g. review of historical outbreak data).
- Mark release recapture (MRR) may overestimate dispersal distances as establishment (e.g. mating and finding suitable host) is not incorporated. MRR can also underestimate the dispersal distances since rare long-distance spread events are very unlikely to be observed in the experiments because the further the insects are from the release point, the less likely they are to be trapped (as they can disperse in all directions, a very large number of traps are needed).
- Outputs from flight mill experiments may overestimate dispersal: it should be noted that in a flight mill experiment the pest does not carry its own weight and that in reality it may not fly all day long and not always in the same direction.

Step 2: Define a general scenario for which the dispersal will be estimated

The general scenario is defined to make sure that all experts have the same understanding of what they are estimating. This general scenario could be one infested plant in an area where host plants are evenly distributed. The time frame should be defined (e.g. one generation cycle or one year).

Step 3: Decide with the risk managers which parameter(s) should be estimated

Depending on the aim of the management measures (e.g. size of clear-cut zone, size of delimiting survey), one or several parameters may be useful to help the risk managers, e.g. median or maximum of the dispersal curve. It should be decided with the risk managers which parameters should be estimated.

Step 4: Follow an EKE process to estimate each parameter and the associated uncertainties

Ideally a working group should be set up with a facilitator used to EKE and experts of the biology of the pest.

The assessors can express their uncertainty in the estimated parameter by eliciting the probability distribution of the parameter following the steps below. An example is given in italics on the elicitation of median dispersal distance to help understanding the different steps.

- Step 4.1: Define a parameter scenario

The EWG should define the conditions (scenario) when the elicited parameter (e.g. long-distance events) may occur and the percentage of events that are likely to be covered by such a scenario. They can also focus on the 'typical spread' that could cover, e.g. 95% of spreading events.

Example: For a given insect population, the EWG agreed that 5% of the population will be involved in annual long-distance dispersal events. These events enabling long distance dispersal are likely to occur if the following conditions are met: part of the population is active above the forest canopy during the flight period coinciding with stable strong winds in one direction.

- Step 4.2: Estimate the range of the parameter

The assessors should provide a range (minimum–maximum) that will include all the estimates and measurements of the parameter.

The assessors should first establish the absolute maximum of the parameter (e.g. natural dispersal distance for the pest).

The assessors should then establish the minimum value of the parameter.

The evidence, reasoning and uncertainties should be documented.

If the objective is the elicitation of the median dispersal distance, the assessors could be asked to imagine an MRR experiment where they have to give their best guess (i.e. median) of the distance where they expect to recapture most of the individuals. First, they discuss the range of possible dispersal distances (minimum and maximum). The estimated median distance will be within this range.

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Table F.1: Fitted values of the uncertainty distribution on the vector local spread (m)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert agreement	100					400		800		1,200					2,000
Expert 1	100					200		400		1,000					1,000
Expert 2	100					300		600		1,000					1,000
Expert 3	300					1,200		1,500		1,800					2,500
Expert 4	75					400		850		950					2,000
Expert 5	200					500		600		800					1,000
Expert 6	105					300		1,100		1,500					800
Expert 7	200					450		650		900					2,000
Fitted distribution	53	95	148	234	335	441	543	767	1,032	1,189	1,388	1,637	1,933	2,204	2,536

Fitted distribution: Weibull (1.5845,967.23), @RISK7.5.

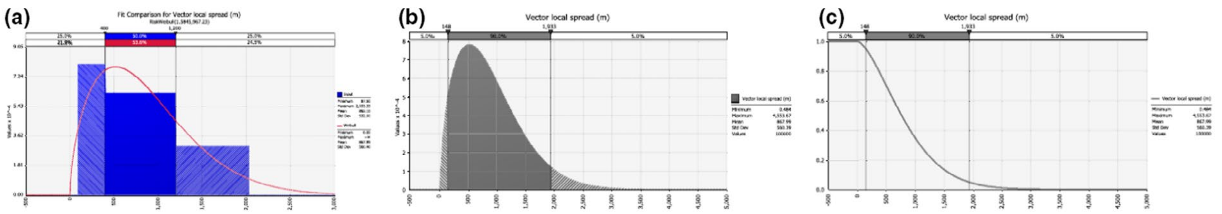

FIGURE 5 Example of an expert elicitation for a maximum spread rate (EFSA PHL et al., 2019) [Colour figure can be viewed at wileyonlinelibrary.com]

- Step 4.3: Estimate the median of the parameter

Given the range of expected minimum and maximum values for the parameter, the experts should give their best estimate of the median of that parameter.

The evidence, reasoning and uncertainties should be documented.

Suppose that the range of dispersal in step 1 is set at minimum =0 m and maximum =1000 m.

Suppose that after discussion the EWG sets the estimated median at 100 m, indicating that the expected dispersal distance is closer to the lower values of the range.

A median value of 100 m implies that it is equally likely that the measured distance of the released pest will be in the range of [0, 100] or [100, 1000] or 50% of the population is expected to spread naturally 0–100 m and 50% of the population is expected to spread naturally 100–1000 m.

- Step 4.4: Estimation of the lower quartile

To get the lower quartile of the parameter, the lower interval is split into two halves of equal probability. If the experts are quite certain about the value of the parameter set before, then the lower quartile should be set near the median.

The evidence, reasoning and uncertainties should be documented.

Given the example above, there is an even chance that the median dispersal distance is between [0, 100] m and [100, 1000] m.

*The median dispersal distance was set at 100 m. How confident is the expert of this value? Does the expert think the median dispersal distance could be **considerably** lower than this?Does the expert think [0, 50] or [50, 100] is more likely?Suppose the experts expect the lower quartile is relatively close to the median and is 75 m, then the lower interval of the lower quartile is [0, 75] m and the upper interval of the lower quartile is [75, 100] m.*

- Step 4.5: Estimation of the upper quartile

To get the upper quartile of the parameter the upper interval is split into two halves of equal probability. If the experts are quite certain about the value of the parameter set before, then the upper quartile should be set near the median.

The evidence, reasoning and uncertainties should be documented.

*The median dispersal distance was set at 100 m. How confident is the expert of this value? Does the expert think the median dispersal distance could be **considerably** higher than this?Does the expert think [100, 500] or [500, 1000] is more likely?Suppose the experts expect the upper quartile is relatively close to the median and is 200 m, then the lower interval of the upper quartile is [100, 200] m and the upper interval of the upper quartile is [200, 1000] m.*

- Step 4.6: Probability distribution of the parameter

When the assessors have determined the range, median and lower and upper quartiles of the estimated parameter, they can make a probability distribution of the parameter reflecting their uncertainty using appropriate software (see Figure 5).

In the example given, the assessors will have a distribution of their expected median dispersal distance.

Step 5 (optional): Use the estimated values for the different parameters of the dispersal kernel to elicit a dispersal curve that best represents the collective expert judgement of the dispersal behaviour of the pest under consideration

Estimating the dispersal kernel will help the risk manager to take an informed decision on the extent of the regulated areas and associated measures. The identified uncertainties on the dispersal behaviour of the pest should be clearly documented. The limitation of the scenario chosen should also be explained. In cases where there is lot of uncertainty about the dispersal kernel, it may be better not to present it as an output as this may give a false impression of certainty that does not exist.

The process detailed in steps 4.1–4.6 can be repeated for each relevant parameter to build a dispersal curve (see Figure 4).

A simplified approach is to assume that a typical dispersal kernel will follow a log-normal distribution. For the pest under consideration, a log-normal distribution can be calculated using the elicited estimated short-range dispersal rate (e.g. the median) and the long-distance dispersal rate (e.g. the 95th or 99th percentile). This step should be performed with the help of a statistician.

Step 6: Produce a report listing the evidence used and the reasoning of the expert working group for the evaluation of the parameter(s) and communicate the output to the risk managers

When the full dispersal kernel has not been elicited, but only a parameter relevant for decision making (e.g. long-distance parameter), it is recommended to communicate to the risk manager the estimated median of this parameter as well as the estimated range in non-technical wording. Rounded values should be used. An uncertainty range of 90% or 95% is considered appropriate (EFSA, 2019) in the EKE process. An example of how an elicited long-distance parameter can be communicated to a risk manager is given below in italics.

An Expert Working Group considered a scenario of long-distance spread to recommend a distance from an outbreak for the establishment of a PFA. The Expert Knowledge Elicitation (EKE) was performed considering [describe here the general scenario defined in Step 2]. *The exercise excluded any human-assisted spread. The combined events enabling long-distance dispersal include* [describe the scenario for long-distance spread defined in Step 4.1]. *The experts judged that* [X]*% of the infestation events within a year would occur during such conditions of long-distance dispersal. Based on a review of the evidence, experts judged that* [X]*% of the infestations will occur after 1 year at a distance of approximately* [median] *km (median value), with a 90% uncertainty range from* [minimum] *to* [maximum] *km.*

A report of the EKE should be produced and made available to the risk managers so that all evidence used as well as uncertainties identified in the elicitation of the parameters are clearly presented. Examples of such reports for *Anoplophora chinensis* are EFSA (2019) and EFSA PHL et al. (2019).

If the dispersal curve has been elicited (Step 5, optional), this can be further communicated to risk managers with the help of a statistician.

It is important that risk managers using these data have sufficient knowledge to understand the EKE process.