Version 3 – IAS Risk Assessment Tool

I. Introduction

II. Background

Invasive species are increasingly recognized for their global and local effects to our economy, social values, and natural environment.

Invasive species are defined as organisms introduced or spread outside their natural past or present distribution, and threaten the environment, the economy, or society, including human health.

Invasive species have affected nearly every type of ecosystem throughout the world causing the extinction of over 110 vertebrate species. In Canada, alien species include at least 27 % of all vascular plants, 181 insects that feed on woody plants, 24 birds, 26 mammals, 2 reptiles, 4 amphibians, several fungi and molluscs and 55 freshwater fish. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) estimated in 2002 that 24% of species at risk in Canada may be threatened with extinction by invasive species (Government of Canada, 2004). In other regions of the world, as many as 80% of the endangered species are threatened and at risk due to the pressures of non-native species (Armstrong, 1995).

Currently there are gaps in our knowledge of invasive species and their effects to Alberta's economy. Information on invasive species is too fragmentary to permit an assessment of total costs, but a preliminary report provides a conservative cost estimate of an annual cumulative cost between $13.3 – 34.5 billion for 16 species in Canada (Government of Canada, 2004). Worldwide, invasive species are generally considered to be the second greatest threat to biodiversity after habitat destruction (Wilson, 1992).

Historically, the process for identifying and managing invasive species in Alberta has primarily been reactive. The focus has often been on the control of established species and the prevention of further spread. Management priorities are primarily determined by considering production losses alone, and are not always allocated in relation to the level of risk. Lesser-known species, for which the effects are not well understood, are often overlooked (e.g., invasive aquatic species such as *Didymosphenia* alga).

III. Purpose

The purpose of the Invasive Alien Species Risk Assessment Tool (RAT) is to provide a systematic and quantitative decision-making system that can be used by governments, companies and individuals. The RAT can assist in the prioritization of alien species for management by their likelihood to establish, spread and adversely affect Alberta's economic base, social values, natural resource productivity and biodiversity.

The RAT allows for a consistent approach to assess the effects of alien species threatening to enter or currently established in Alberta. The tool outputs can provide a focus for a concerted effort on containing, controlling or eradicating alien species across jurisdictions. In addition,

information from the RAT can be used to inform and support communication strategies, and early detection/rapid response initiatives to prevent the establishment and spread of alien species.

Using this tool, risk assessments can be completed relatively rapidly. This supports the re-examination of a species over time with the addition of new information.

IV. Development

The initiative to develop Alberta's Invasive Alien Species Risk Assessment Tool was spearheaded by the Inter-departmental Invasive Alien Species Working Group (IASWG) late in 2006. Staff from the following Alberta ministries participated in the project: Agriculture and Rural Development; Environment; Tourism, Parks and Recreation; Sustainable Resource Development; and Transportation.

AMEC Earth & Environmental (AMEC) was retained by the IASWG in January 2007 to develop the groundwork for the RAT. AMEC's work involved a literature review of existing risk assessment systems and risk indicators used in these systems. This was a critical stage to determine the initial functionality of the risk assessment system, select appropriate risk indicators, and complete the first draft of the RAT.

The draft version of the RAT was widely distributed to invasive species managers in Alberta and across Canada. Feedback from this review was collected via an online survey and incorporated where appropriate.

In March of 2007, an expert panel consisting of national and international risk assessment and invasive species specialists was assembled to further review and improve the draft RAT. Of the numerous comments from the expert panel, one focused on the over-simplification of the social and economic effects section of the tool. This led to the contracting of Gardner Pinfold Consulting to propose modifications and extensions to that specific section of the tool.

The duration of 2007, and the early part of 2008 was used by the IASWG to further review and refine the RAT to generate version 2. Golder Associates were retained by the IASWG in January 2009, to test various terrestrial and aquatic species thru the RAT generating test results to further analyze the tool. From the results and feedback acquired, the IASWG made final edits to generate the current version.

V. Tool Characteristics

The Risk Assessment Tool allows a predictive, quantitative assessment of the likelihood of adverse effects from alien species in the assessment area. The assessment consists of a series of distinct indicators that are arranged in a systematic manner to assess overall invasiveness of a species. To assess each indicator, a number of questions are posed. The answer for each question corresponds to a numerical score. Each indicator is given a score that is then tallied into an overall total score. The total score is a measure of the "invasiveness" of the species.

The tool has been constructed to be simple to use assuming the assessor will have a minimum level of expertise. Although guidance and rationale are provided on interpretation of the questions and subsequent scoring, it is assumed the assessor will have some familiarity with the scientific basis of the questions and of ecology in general, as the assessor will need to identify reference sources used to address various risk evaluation factors.

The RAT is based on commonly accepted principles of risk assessment and scientifically defensible ecological properties of invasive species. The format of the tool was chosen following careful consideration of the types of frameworks or tools used in other jurisdictions, and those proposed by academic researchers. The chosen risk assessment framework is modified from an approach which has been validated for a variety of types of organisms, and has been used successfully in several other jurisdictions to rank potential invasive species. For each of the risk questions used to screen the species, the underlying scientific rationale or justification for its inclusion is provided. The ecological theory or scientific studies supporting the risk indicator are cited.

The RAT evaluates the likelihood of introduction and establishment of invasive species, but does not provide an estimate of the temporal scale of invasions. While it is possible to identify certain biological characteristics that allow organisms to invade new areas and avenues by which they might be introduced to new areas, it is impossible to predict the rate at which the invasion will actually occur. Past experience suggest invasions by different species do not proceed at the same rate nor do introductions of the same species into different environments. Due to variable climatic conditions or specific features of the introduction (e.g., number of individuals introduced), there is sometimes a post-introduction lag phase that precedes a rapid population increase. However, the risk assessment tool is flexible and supports a re-examination of a species over time with the addition of new information.

CALCULATION OF RISK

Risk = Exposure X Effect

Environmental Risk = Exposure X Environmental Effect

Economic Risk = Exposure X Economic Effect

Social Risk = Exposure X Social Effect

Overall Risk = Environmental Risk + Economic Risk + Social Risk

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Exposure:
([Present Status + Introduction] x [Survival]) + [Establishment] + [Dispersal Ability]

Where:

[Present Status + Introduction] = [(1.1 +1.2 + 1.3) + (1.4 + 1.5 + 1.6 + 1.7 + 1.8)]
[Survival] = [1.9 +1.10 + 1.11 + 1.12]
[Establishment] = [1.13 + 1.14 + 1.15 + 1.16 + 1.17 + 1.18 + 1.19]
[Dispersal Ability] = [1.20 + 1.21 + 1.22]

And

Exposure score = [[(1.1 +1.2 + 1.3) + (1.4 + 1.5 + 1.6 + 1.7 + 1.8)] x [1.9 + 1.10 + 1.11 + 1.12))]] + [1.13 + 1.14 + 1.15 + 1.16 + 1.17 + 1.18 + 1.19] + [1.20 + 1.21 + 1.22]

Environmental Effect:
[Σ (2.1 … 2.13)]

Economic Effect:
[Σ (3.1 … 3.14)]

Social Effect:
[Σ (4.1 … 4.09)]

SECTION 1 - BIOLOGICAL CHARACTERISTICS/EXPOSURE

Present Status (Is it here?)

Rationale: The introduction of alien species into the environment poses a severe threat to biodiversity as well as, natural-resource based industries. New introductions of alien species are more likely to occur within habitats as the global trade market increases. Of all the introduced alien species, 10-20% will become invasive. When an alien species colonizes a new habitat it out-competes native species for essential resources such as, light, water, space and nutrients (Arriaga et al., 2004).

In the short-term a species may not enter a region, however, over time this species may be able to invade the area through natural or anthropogenic processes. Furthermore, through adaptation/mutation, new characteristics arise to enable the survival/spread of this species into the vicinity. Therefore, it is important to consider if a species is present in areas adjacent to the area being assessed. The combination of the organism's dispersal characteristics, mechanisms of introduction into an area, biological requirements, proximity to the assessment area, and other factors described in further questions are used to assess the invasive risk (AMEC, 2006).

The presence, abundance and distribution of a species within an assessment area are attributes of its potential to become invasive. A weed in one part of the country may become invasive in another province (Haber, 2002).

1.1 Is the species present in the assessment area?

0 = Not present
3 = Likely not present
6 = Likely present
9 = Confirmed
9 = Unknown

Guidance: Does the species currently exist within the area of assessment? It is important to remember that a species does not have to be physically viewable in the assessment area to exist within the environment. A species can persist in the environment as a seed, spore, or egg which can survive in a dormant state until suitable conditions arise. Purple Loosestrife (*Lythrum salicaria*), for example, can produce up to three million seeds per plant which can remain viable in the seed bank for up to twenty years (Graham, 2003). Is there evidence of a persistent propagule bank in the assessment area? Can the propagule remain viable in the soil or environment for more than a year? Can the propagule survive in adverse environmental conditions such as drought, lack of light to germinate or extreme weather?

1.2 What is the abundance of the species in the assessment area?

0= No Abundance
1 = Rare / Trace
2 = Occasional
3 = Scattered
4 = Abundant
4 = Unknown

Guidance: How large is the current population within the assessment area? Abundant species form dominant populations as they possess a wider geographical distribution than those of scattered or isolated distributions. Scattered populations tend to be less successful invaders as they have small ranges (Williamson & Fitter, 1996).

- **Rare/ Trace** population - a sporadic number of species (i.e. less than 1% plant cover per unit of measure).
- **Occasiona**l population - a low or occasional number of species (i.e. between 1-5% plant cover per unit of measure).
- **Scattered** population - a moderate or scattered number of species (i.e. between 5-25% plant cover per unit of measure).
- **Abundant** population - a fairly dense or a high number of species (i.e. between 25-100% plant cover per unit of measure).

1.3 How is the species distributed within the assessment area?

0= No distribution
1 = Isolated
2 = Localized
3= Widespread
3 = Unknown

Guidance: What is the number of individuals present within the assessment area? How large of an area does the species cover within the assessment area?

- **Isolated** population- covers a small area with subpopulations limited to one or a few.
- **Localized** population- covers a moderate proportion with populations encompassing several or moderate sized areas.
- **Widespread** population- fairly common with many populations present over a large area.

Introduction (Can it get here?)

Rationale: Invasive species do not respect political borders between continents, neighbouring countries, or boundaries among ecosystems within Canada. Alien species can move within jurisdictions, regions, provinces and territories to become invasive. As globalization increases, so will the potential risk of additional introductions of alien species. Introductions can be intentional or accidental; authorized or illegal; beneficial or damaging having severe and irreversible consequences. Pathways for invasion can be natural, anthropogenic or a combination of both. Anthropogenic pathways are either by indirect transport or direct trade of a species which is later found to be invasive. Other vectors include ballast water; pet; aquarium or horticulture trade; recreation boating; "hitchhikers" on goods and packing materials; stowaways on various modes of transportation (ships, planes, trains and vehicles); and wildlife disease (Government of Canada, 2004). Most successful invaders rely on some form of human-mediated transport, such as, ballast water (Ricciardi & Rasmussen, 1998) or propagules on trucks and all-terrain vehicles which are more difficult to monitor, control and detect at points of entry. As remote areas are opened up for resource extraction, this becomes an even greater concern. The movement of goods can be restricted under the World Trade Organization Agreement on Sanitary and Phytosanitary Measures, preventing the entry or exports of recognized pests that may threaten agriculture and forest crops. An example is the closure put on Canadian beef because of the discovery of Bovine Spongiform Encephalopathy (BSE) (Government of Canada, 2004).

One way in which successful invaders can expand their range into new locations is by adapting to local conditions. Propagule pressure which is determined by number of individuals released in one event and the number of events leads to increased likelihood of successful invasion (Lockwood et al., 2005; Leung et al., 2004). A high number of initial founders results in higher genetic variance and allows a rapid response to natural selection (Parker et al., 2003).

The ability of the species to survive in transit and the low probability of detecting the organism at an entry point reflect the effectiveness of the invasion pathways. Organisms able to survive for long periods of time and are hard to detect have greater potential to become invasive because their pathways are more effective in allowing them to enter into the assessment area (AMEC, 2006).

1.4 What are the potential invasion pathways into the assessment area?

3 = Only natural pathways
6 = Only anthropogenic pathways
9 = Combination of natural and anthropogenic pathways
9 = Unknown

Guidance: How effective are the modes of natural dispersal? Does the species have adaptations that enhance its ability to spread? For example, wings or pappi on seeds enable them to be carried by wind or hooks enabling the seed to attach to animals. Are the propagules able to be dispersed by wind, water or other biological agents? Does the organism form persistent resting bodies? For example, seeds with long dormancy periods or spores. How close is the species to the area of assessment? Is the organism able to move independently (i.e. larvae)? Is the species an ornamental?

Intentional anthropogenic introductions or pathways are the deliberate movement and/or release by humans of an alien species outside of its natural range. For example, live bait, unauthorized stocking (e.g. goldfish/koi), pet trade, biological control and ecosystem restoration or reclamation. Unintentional anthropogenic introductions or pathways are all other introductions by humans which are not intentional. For example, commercial shipping (i.e. ballast water), recreational boating (i.e. transportation of IAS on boats from lake to lake), range expansion (i.e. canals, dams, diversions) and garden materials (i.e. soil). Does the organism have anthropogenic means of invasion (intentional or unintentional)? Is there a lot of transport from the source area through the assessment area by anthropogenic means? Does this species have a known mechanism of human introduction? If so, what is the frequency of shipments into province/area, the number of individuals associated with each conveyance, the intended use of commodities, season of arrival and distribution of commodities? Is the species easy to transport and disguise?

1.5 What is the likelihood of re-introduction from the source of the invasion?

0 = Unlikely, original intro one-time occurrence
1 = Sporadic
2 = Continuous / ongoing re-intro possible
2 = Unknown

Guidance: The source area of the invasive species can consist of either its native range (e.g. Europe or Asia) or its newly invaded range (e.g. quarter section in southern AB). What would be the frequency of this species being introduced into the assessment area? Is it a contaminant of crops, hay, seed or other commercial entities that are transported through the assessment area? Can it attach itself to vehicles/other transportation vectors? Is it a desirable ornamental species? Does the species have high market value?

1.6 How likely is the organism to survive in transit?

0 = will not survive
1 = limited survival
2 = likely to survive but number of individuals originally transported is reduced

3 = likely to survive with no negative effect on the number of individuals being transported
3 = Unknown

Guidance: Given the most likely mechanism for human introduction, will the organism survive conditions during transit (e.g. duration, temperature, oxygen)? Will the organism in transit be an adult, or a resistant life stage (i.e cyst)? Are biological control measures in place and if so, will the organism survive existing control measures, such as phytosanitation? Survival is **limited** if mortality is greater than 95% of individuals where as **no negative effect to population size** is generally the case if mortality is less than 5%.

1.7 What is the likelihood of detecting the organism along its invasion pathway(s) into the assessment area?

1 = easy to detect
2 = somewhat difficult to detect, mechanisms for detection exist
3 = somewhat difficult to detect, no mechanisms for detection exist
4 = likely to be missed
4 = unknown

Guidance: Given existing inspection/control measures, how likely is it that the species might evade detection? Does the organism travel as a parasite with a larger organism? Would all life stages be detected, or is it possible that propagules would not be detected? Is this species easily discernable from native species? Is the species easy to detect by visual inspection? Are authorities even looking for the species?

1.8 If introduced, how many individuals are likely to be released?

1 = one
2 = few individuals, one introduction event
3 = few individuals, multiple introduction events
4 = many individuals, one or multiple introduction events
4 = unknown

Guidance: In the event of an introduction, is the size of the group released likely to be large or small? This will depend on sector use and the mechanism of release. Intentional release of a single aquarium species will result in only one or at most a few individuals released. The number of individuals released from catastrophic failure of containment systems in aquaculture would be higher. Are repeated introductions to the same environment likely? Introductions can be intentional or accidental; authorized or illegal; beneficial or damaging having severe and irreversible consequences (Government of Canada, 2004).

Survival (Can it survive?)

Rationale: The Alberta landscape is largely a disturbed one. A species response to disturbance is related to its potential to colonize. Although species adapted to human disturbance (e.g., vermin, agricultural weeds) tend to invade with greater frequency (Fox and Fox, 1986), non-native colonizers restricted to disturbed habitats may pose less of a risk to natural subsystems compared to species capable of invading relatively intact communities (Hiebert, 1990; Ruesink et al., 1995).

Some species can only invade in areas where major disturbances have occurred (e.g., fire, forestry, habitat alteration), usually within the past 20 years. Other species are able to establish in mid- to late-succession natural areas where minor disturbances (tree falls, hiking trails, stream bank erosion) may occur, but no major disturbance has occurred in past 20-75 years. Highly invasive species are able to colonize intact natural areas with mature, established communities or otherwise healthy systems with no major disturbance for at least 75 years (Heffernan et al., 2001).

Organisms with high phenotypic plasticity (non-genetic variation in response to environmental changes), or a “general purpose genotype” are more likely to be able to adapt to a variety of environmental conditions (Baker, 1965). Phenotypic plasticity allows for the success of populations founded by relatively few individuals (Parker et al., 2003). Native range size is a measure of habitat breadth, or generality, and is related to invasive success (Forcella and Wood, 1984; Reichard, 1994). Species with a wide habitat and climate tolerance, in theory, are more likely to encounter conditions in new areas conducive to survival and reproduction (Ruesink et al., 1995). The introduction and spread of invasive species are influenced by numerous variables such as climate, habitat and diversity in floristic zones (Haber, 2002).

1.9 How much habitat is available for the species within the assessment area?

0 = No available Habitat
3 = Less than half of the area
6 = Majority of the area
9 = Entire area
9 = Unknown

Guidance: Does the organism have specific habitat requirements? Are these requirements within the assessment area? Is this habitat influenced by humans? Is this habitat created artificially by humans? Does it require a certain soil type to germinate? Is it a species that invades wetlands only? Does it require year-round flowing water? Does it prefer undisturbed areas, or croplands? Risk assessors may use various sources of data to evaluate habitat, for example, information on soil types (CanSIS),

water temperature for fish, or land cover type. What percentage of the assessment area has physical habitat available for the organism?

1.10 How can the climate (i.e. weather) within the assessment area affect the survival of the species?

0 = Prevents survival
3 = Limit survival
6 = No limiting effect
9 = Promote survival
9 = Unknown

Guidance: Based on climate variables such as, air temperature (max and min), rainfall, snowfall, humidity, water temperature, degree growing days, etc. does the assessment area have the appropriate climate for the species? How much of the assessment area has the appropriate climate for this organism? Is the species subject to or vulnerable to weather conditions? Can the environment limit the organism? Are there extreme weather events that can limit the organism? Mountain pine beetles, for example, exhibit high winter mortality rates during temperatures of -32 degrees Celsius or below, for a period lasting 5 consecutive days or more (Leatherman, 2007). Do periodic weather events occur limiting the persistence of the species?

1.11 Does the species have a broad tolerance to environmental conditions?

1 = establishes only in a narrow range of environmental conditions
2 = rarely establishes in less than ideal conditions
3 = sometimes establishes in less than ideal conditions
4 = can establish in a broad range of environmental conditions
4 = unknown

Guidance: How widespread is the species in its native area? Does it survive in a wide range of temperatures? Can it tolerate extremes of salinity or disturbance? Does it have the ability to disperse by natural or anthropogenic means? Can it tolerate less than ideal conditions? Has the species developed adaptations to survive in less than ideal conditions? Seeds, spores and eggs of species can survive in the environment as a dormant state for numerous years until suitable conditions arise. Most seeds of Canada Thistle (*Cirsium arvense)*, for example, germinate within the first year however, seeds can remain dormant in the soil for up to 20 years (AIPC, 2009).

1.12 Has the organism demonstrated the ability to colonize undisturbed / natural communities?

0 = Does not invade natural/ undisturbed communities
2 = Colonizes in communities with major disturbance only
4 = Colonizes natural communities (infrequently) but prefers communities with major disturbances (frequently)
6 = Often colonizes natural/ undisturbed communities
6 = unknown

Guidance: Is the species found in natural, undisturbed areas? Does the species have the ability to create its own opening in an undisturbed area? Does the species create the disturbance? How aggressive is the species?

Establishment (Will it establish?)

Rationale: One factor necessary for rapid establishment of an invasive species is frequent reproduction. Successful invasions involve a steadily increasing population. The risk of invasion is often associated with the intrinsic rate of population growth, or with traits such as, fecundity and generation time (Ruesink et al, 1995). Rapid growth is one mechanism that allows a species to avoid low abundance in an area that tends to lead to extinction. In a study of 45 species of introduced fish in the Great Lakes, Kolar and Lodge (2002) identified rapid growth rate as a significant feature leading to the establishment of a species (but not as a predictor of the rate of spread of the species). Rapid growth is one way in which species offset losses to natural predators in their native range (e.g. grazed plants); without their natural predators, alien species with rapid growth can gain a strong advantage over native species (Shea & Chesson, 2002).

Sexual reproduction produces propagules that may be capable of long-distance dispersal and allows for the possibility of forming gene combinations favourable to the new environment. In plant communities, and some aquatic invertebrates where male gametes are dispersed by water, the effective rate of invasion can be dramatically faster if invasive species hybridize with native species (Petit, 2004). In most cases, dispersal of male gametes (pollen) is much more rapid than dispersal of the seed. When hybridization with native females results in viable offspring, the progeny can be considered to be non-native. Hybridization has also been proposed as a mechanism to explain the observation that successful invasion often requires an initial lag period and/or multiple introductions (Ellstrand and Schierenbeck, 2000). Progeny of hybridizations may enjoy potential genetic benefits over their progenitors.

Asexual reproduction is a secondary means of reproduction requiring less time and energy when under harsh environmental conditions. In certain conditions, this is the only way to reproduce (e.g. if pollinators are absent). This is a very effective tool for invasive species because a single individual can colonize a new habitat and establish a population. In the annual cycle, species are capable to choose the mode of reproduction maximizing the species potential when conditions are favourable.
Some species can choose the mode of reproduction when conditions are most favorable maximizing the species potential in the annual cycle (Encarta, 2008). In plants, this additional mechanism allows the plant to increase the rate of reproduction when sexual reproduction might not occur (Madsen et al., 1988). Vegetative reproduction also allows an adapted ecotype to be maintained providing reproduction assurance (Parker et al, 2003) and can allow the species to escape certain control methods such as cutting or burning (Madsen et al., 1988).

Successful invasion can also be a result from effective competition for resources, or alternatively, release from competition. An invader with no natural predators is released from competition and has very low maintenance requirements (Shea and Chesson, 2002). Consequently, such species can be very effective competitors.

1.13 Are the organism's specific requirements for reproduction available in the assessment area?

0 = Specific requirements not available
2 = Some specific requirements are available
4 = Most requirements for reproduction are available
6 = Species requires no specific requirements, or all requirements are available.
6 = Unknown

Guidance: Does the organism require conditions for germination or reproduction that may or may not be available in the assessment area (i.e. specific precipitation, length of season, soil conditions, food availability, temperature or light requirements)? Are there special pollinators required for fertilization? Do seeds require open soil and disturbance to germinate, or can the seeds germinate in existing vegetation in a wide range of conditions? Do the seeds require fire to germinate? Does the organism require flowing water, a minimum oxygen concentration, certain aquatic substrates for eggs?

1.14 What is the frequency of sexual reproduction?

0 = Almost Never
1 = Less than once a year
2 = Once per year
3 = More than once per year
3 = Unknown

Guidance: What is the minimum generative time? Some organisms have a low rate of reproduction, generating offspring only once every few years; others have several reproduction events (e.g. litters, clutches, hatches, etc.) in one year. Is it a biannual, annual, biennial, or perennial plant?

1.15 What is the rate of growth to reproductive maturity?

1 = Slow growth
2 = Moderate growth
3 = Rapid growth
3 = Unknown

Guidance: How long is the duration to reproductive maturity (i.e. weeks, months or years)? Is the organism known to reduce the age-at-maturity in response to environmental stress?

- Slow growth- A species would miss two or more reproductive opportunities before being able to reproduce (e.g. two to four life cycles stages). Salt Cedar

(Tamarix ramosissima) would be an example of slow growth as it reaches reproductive maturity in its third year of growth (Galveston Bay, 2007)

- Moderate growth- A species would miss one reproductive cycle before being able to reproduce (e.g. an animal species that spends one year as a non-reproductive yearling before reaching maturity taking one life cycle to mature). Oxeye Daisy would be an example of moderate growth as it reaches reproductive maturity in one growing season (Alberta Invasive Plant Council, 2008).

- Rapid growth- A species would be able to reproduce as soon as environmental conditions allow for it taking less than one life cycle amounting to a higher frequency of reproduction (e.g. a seed germinates and grows into a reproductive plant within the same growing year or a litter leaves the nest and reproduces in the same summer). The Norway rat (Rattus norvegicus) and the Cabbage white butterfly (Pieris rapae) are examples of rapid growth. The Norway rat reaches reproductive maturity within three weeks while the Cabbage white butterfly can take three to six weeks (Galveston Bay, 2007).

1.16 How many viable offspring can the organism produce at one time?

0 = Very few or none
1 = Few
2 = Moderate
3 = Many
3 = Unknown

Guidance: Does the organism produce viable offspring? Seeds of weedy species commonly remain viable in the soil for many years (Haber, 2002). The seeds of an Annual Sowthistle (*Sonchus oleraceus L.*), for example, can remain viable in the environment for four years (Ministry of Agriculture & Lands, 2002). Does the organism have higher fecundity than other organisms its size? For most plants, less than ten seeds annually is considered **few**, while over 1,000 seeds per plants annually is considered **many** (Heffernan et al., 2001). For fish, greater than 10,000 eggs per kg are generally considered **many** (Copp et al., 2005). The fecundity of organisms can vary by each species therefore, it is important to use an average in the examples above to examine high reproductive potential versus low reproductive potential.

1.17 Is asexual reproduction (e.g. vegetative reproduction or self-fertilization) an important aspect of this organism's reproduction?

0 = None
1 = Not important
2 = Moderately important
3 = Highly important
3 = Unknown

Guidance: Some plants may form new, viable individuals from non-reproductive plant parts or fragments. Fragments of Eurasian Watermilfoil (*Myriophyllum spicatum*), for example, can root in sediment and form new plants. Does the plant have quickly spreading rhizomes that may root at nodes? Does it re-sprout readily when cut, grazed or burned? Other organisms may self-fertilize, or have hermaphroditic forms under certain conditions.

1.18 Does the opportunity to hybridize naturally with species present in the assessment area exist?

0 = No close relatives, little to no chance of hybridization
1 = One or two hybridization opportunities but likelihood of occurrence is low
2 = Many hybridization opportunities exist but likelihood of occurrence is low
3 = Many hybridization opportunities exist and likelihood of occurrence is high
3 = unknown

Guidance: Is there previous evidence of hybridization? Does hybridization affect the ability of the species to establish a population? Can the organism use males of a native species to activate eggs? Are there species present within the assessment area that might hybridize easily with the invasive species? Are there species in the assessment area that are likely to hybridize easily with this species? A hybridization opportunity would include the presence of a species where hybridization is a possibility. Likelihood of occurrence (low or high) is related to the potential interaction of the two species based on habitat requirements, population size etc. of each species. Is the progeny viable and able to reproduce? Does the hybridized species have the ability to revert back to the invasive species (e.g. ox-eye daisy)?

1.19 Are there known natural control agents, including predators, in the assessment area?

0 = Predators and/or control agents are or have severely to completely restricting population growth
1 = Predators and/or control agents are present and or have are minimizing population growth
2 = Predators and/or control agents are present but are not or do not have the potential to effecting population growth
3 = No known control agents present
3 = Unknown

Guidance: Organisms in their native habitat have competitors or predators that limit their population growth, but such control agents may be absent in the assessment area. These could include predators/grazers that directly feed on the organism, parasites of the organism, or competitors for resources.

**If the species is not currently present in the assessment area, answer as if it was present.

Dispersal ability (Will it spread?)

Rationale: The patchy nature of landscapes historically limited populations spatially from dispersing into each other (Cain et al., 2000). Widespread dispersal is a key trait in successful invasions (McAlpine & Jesson, 2007) as the rate of a species invasion is directly related to its dispersal (Ruesink, 1995). However, this may not reflect the probability of establishment (Ruesink, 1995).

Dispersal is a natural adaptation to increase the probability of offspring survival (McAlpine & Jesson, 2007). Many key aspects of plant biology are influenced by dispersal events including population dynamics, evolution of populations, metapopulations dynamics, biological invasions, and the dynamics and diversity of ecological communities (Cain et al., 2000). In plants, dispersal is essential for seedling establishment as few survive under the parent canopy (McAlpine & Jesson, 2007).

Rafting is an important dispersal mechanism for marine organisms as it increases geographical ranges. Many bryozoans, for example, live on algal holdfasts which are the most likely part to break off promoting rafting (Watts et al., 1998).

Transportation is a major anthropogenic vector for the introductions of alien species (von der Lippe & Kowarik, 2007; Watts et al., 1998). The rate of long distance dispersal is increased by human-mediated transport along roadsides, railways and international waters promoting species dispersal farther than their natural ability (Ricciasrdi & Rasmussen, 1998; von der Lippe & Kowarik, 2007; Watts et. al., 1998). Oceanic species can cross natural barriers by fouling in the hulls of ships to suitable habitat along shipping routes. This is dependent on traffic and environmental tolerance of the fouling organisms (Watts et al., 1998). The construction of roads disturb the environment forming appealing habitats for alien species while the corridors aid in dispersal which may lead to the establishment of a new population of species (Christen & Matlack, 2006; von der Lippe & Kowarik, 2007). Propagules rely on mud or other substrates for seed attachment to vehicles during transportation. A high proportion of alien species in urban areas is a reflection of the dispersal by vehicles (von der Lippe & Kowarik, 2007).

The realized rate of increase of an invasive population is determined by the intrinsic rate of increase of the species (fecundity), mortality, habitat suitability, resource abundance, competition, and multiple other properties of the system. For those species with a previously recorded history of invasion, population doubling time is a simple measure of realized rate of population increase. The conditions of one invasion will not necessarily be duplicated, but it can be reasonably expected that a species with a demonstrated rapid rate of population expansion in one area has the potential to behave similarly in another (AMEC, 2006).

1.20 To what degree can the organism disperse naturally?

0 = No potential
1 = Local dispersal
2 = Regional dispersal
3 = Provincial dispersal
3 = Unknown

Guidance: Ability for dispersal is related to certain biological properties or adaptations, including wings and pappi for seed dispersal, bladders for water dispersal, and bristles for animal dispersal, etc. Propagules may be dispersed by physical factors such as, wind or water, or by biological agents. Small seeds can potentially be dispersed long distances. Does the organism produce persistent propagules (e.g. cysts)? Is the primary mode of spread passive or active dispersal (e.g. larvae)? Does the species utilize rapid water for dispersal?

- **Local dispersal-** a plant species that would not spread over 1000 m/year from its "parent" plant or an aquatic organism that would not be able to spread beyond its original water body (or its current area within a large water body).
- **Regional dispersal-** a species has the potential to invade neighbouring water bodies or spread up to 100 km per a single dispersal event.
- **Provincial dispersal-** the ability of the invasive to spread beyond neighbouring habitats to invade anywhere in the province. This is assisted by characteristics such as, very light seed and/or potential attachment to migratory birds.

1.21 To what degree will anthropogenic mechanisms assist the dispersal of this species within the assessment area?

0 = No mechanisms
1 = Few mechanisms
2 = Several mechanisms
3 = Many mechanisms
3 = Unknown

Guidance: Does the organism have anthropogenic means of invasions? Is there a lot of transport from the source area through the assessment area by anthropogenic means? Does this species have a known mechanism of human introduction? If so, what is the frequency of shipments into province/area, the number of individuals associated with each conveyance, the intended use of commodities, season of arrival and distribution of commodities? Is it easy to transport and disguise? Does the dispersal of the species by anthropogenic means enhance natural dispersal? Plant species, for example, with wind-catching plumes can be dispersed long distances anthropogenically by trains (Christen & Matlack, 2006).

- **Few mechanisms-** a species being able to disperse anthropogenically by one to two means. A mite (*Varroa destructor*), for example, has limited human vectors

for dispersal as it relies on queen bees for introduction and movement from colony to colony (Sanford, et al., 2007).

- **Several mechanisms-** a species being able to disperse anthropogenically by three to five different means. A Zebra Mussel (*Dreissena polymorpha*), for example, is limited to water dispersal associated with boats and other water crafts (e.g. ballast water, attaching to hulls, anchors or chains) (Wikipedia, 2008).
- **Many mechanisms-** a species being able to disperse anthropogenically by five or more means. Canada Thistle (*Cirsium arvense*), for example, can be dispersed by humans via cultivation, transportation of seeds, contaminant in topsoil and wind turbulence behind vehicles to name a few (Garnier et al., 2008).

1.22 What is the rate of dispersal once the species is released or disperses into a new area?

0 = Does not disperse
1 = Slow rate of dispersal
2 = Moderate rate of dispersal
3 = Rapid rate of dispersal
3 = Unknown

Guidance: The apparent rate of dispersal is based on new local reports of populations or expansion of the range of the species. Frequently, invasive species have rapid population doubling, however, success rate of surviving, viable offspring is not always high. What is the time required for the species to successfully double its number in a discreet population or an affected area? For aquatic species a doubling time of more than 20 years is considered **slow**; a doubling time of less than 3 years is considered **rapid**. For plant species, a population doubling time of more than 50 years is considered **slow**; a doubling time between 10 and 50 years is considered **moderate**; doubling time of less than 10 years is considered **rapid** (Heffernan et al, 2001). Doubling time for one group of species is not equal to another group of species so each must be considered independently (i.e. do not compare the doubling time of aquatic invertebrates to that of terrestrial plants).

SECTION 2 - ENVIRONMENTAL EFFECTS

Rationale

Alien species can have a range of effects on the environment. They can interfere with the species that make up ecosystems and change the way they function and interact.

Competition

Exploitative competition occurs when an alien species competes with other species in the assessment area for one or more of the same limited resources (e.g. food, sunlight, water, soil, nutrients, or space). In addition, non-exploitative competition may also occur. In this case, the exotic species may cause harm to other species without a direct use of available resources. For example, some alien species can release chemical compounds that have antagonistic (or allelopathic) effects on other species.

Competition among species is complex and ecosystem-specific. As such, predictive indicators of competitive success are difficult to identify. In the absence of an invasion history, it may be possible to predict effects from the invasion history of functionally similar organisms (Byers et al., 2002; Ricciardi, 2003). For example, the ecological effects of the poorly understood Limnoperna, an invasive freshwater mussel, are similar to those of Dreissena, with respect to macroinvertebrate density, taxonomic richness, and enhancement of diets of local fish (Ricciardi, 2003). Similarly, if the invasive species is known to out-compete certain species in its native range, it is possible it may also effectively compete with similar species in Alberta. The outcome of invasions often depends on the diversity of functional groups within the native community. The presence of native organisms of functionally similar groups (i.e., that share morphological or physiological traits) appears to be important in invasion resistance (Pokorny et al., 2005).

Predation and Parasitism

By preying upon or parasitizing native species, an alien species can be the cause of reduction of native populations. The potential may exist for alien predators and parasites to cause profound losses of native species and communities (Fritts and Leasman-Tanner, 2001, Mack et al., 2000). Quite likely, the native species being parasitized or preyed upon is (or are) not well-adapted to the new threat and are highly vulnerable.

Effects of predators need to consider both the breadth and severity of mortality effects in a community. Predators vary in their degree of predatory focus, from high (specialists, preying on one or few species) to low (generalists, preying on a variety of species). The effects of generalist predators on an ecosystem or community are generally greater than that of specialists (Symondson et al., 2002). This is not the case, however, if the

species preyed upon by a specialist is of particular importance to the integrity of the system.

Effects of parasites are usually less direct and dramatic than those of predators, but an assessment of effects must still consider breadth and severity. Typically, parasites are very specialized in their focus, with life cycles that are dependant on specific host species. In a community where they belong, parasites do not usually cause direct mortality and profound reductions in their host populations (which would be detrimental to themselves) (Deredec and Courchamp, 2003). However, a new parasite can reduce the fitness of a host organism by varying degrees. By so doing, it may cause an incremental increase in mortality and push a native species population below an ecological threshold (Groffman et al., 2006) (analogous to “the straw that broke the camels back”). If the native species affected is of high concern or importance to the overall community integrity, the effects of parasitism would be greater.

Host or Vector

The effects of an alien species can be amplified indirectly if that species acts as a host or vector of a existing pest that negatively affects populations of native species, species at risk, or species of management concern. As a host, the alien species may provide additional food or a substrate on which a known pest may feed, live and/or reproduce. In turn, the presence of the alien species may allow existing pests to expand in range or population size. As a vector, the alien species assists in the transfer of existing pests (often pathogens and parasitic organisms) to other species (Lougheed, 2007). This may increase the likelihood of a native, at-risk or managed species being exposed to existing pests.

Hybridization

If an invasive species hybridizes with a native species it may lead to a decline in the size or integrity of the native species population. Hybrid progeny may potentially have genetic benefits over their progenitors which allow them to outcompete native populations which may lead to a decline in the native population and replacement of native genotypes (Campbell, 2002). Hybrid progeny will also reproduce with native populations, further reducing and diluting the genetic presence of the native population (Simberloff, 2000).

Abiotic or Ecosystem Processes

Invaders with dramatic effects at the ecosystem level often involve a form not represented in the native community (Ruesink et al., 1995). There are numerous examples of exotic species that alter ecosystem processes such as, fire occurrence or frequency (e.g. cheatgrass in western grasslands; D’Antonio & Vitousek, 1992), erosion and sedimentation rates, hydrological regimes, nutrient regimes (e.g. the nitrogen-fixing tree, M. faya, in Hawaii). Some non-native invaders can cause ecosystem

destabilization or completely transform natural systems so that they can no longer support native species.

Guidance (for questions 2.1 through 2.12)

The alien species will have **No Effect** when it does not affect growth, reproduction, abundance, or distribution of any species within the assessment area.

A **Mild Effect** would result when the effects of the alien species on the growth and reproduction of a single species decreases its abundance, but not its distribution within the assessment area.

A **Moderate Effect** would result when the effects of the alien species on the growth and reproduction of a single species decreases the distribution of that species within the assessment area. Alternatively, the alien species may affect the abundance of several species, but not necessarily affect their distribution.

A **Severe Effect** would result when the effects of the alien species on growth or reproduction results in the elimination of a species from the assessment area within the assessment area. Alternatively, the alien species may diminish the distribution of several species in the assessment area.

Competition

2.1 Is the species known to compete for resources with desired non-native species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

2.2 Is the species known to compete for resources with secure or abundant native species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

2.3 Is the species known to compete for resources with a sensitive or "at risk" species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Predation – Parasitism

2.4 Is the species a predator or parasite of a desired non-native species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

2.5 Is the species a predator or parasite of secure or abundant native species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

2.6 Is the species a predator or parasite of a sensitive or "at risk" species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Host - Vector

2.7 Is the species a host or vector for known diseases, parasites, or pests that will cause harm to desired non-native species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

2.8 Is the species a host or vector for known diseases, parasites, or pests that will cause harm to secure or abundant native species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

2.9 Is the species a host or vector for known diseases, parasites, or pests that will cause harm to a sensitive or "at risk" species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Hybridization

2.10 Is the species able to hybridize with desired non-native species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

2.11 Is the species able to hybridize with secure or abundant native species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

2.12 Is the species able to hybridize with a sensitive or "at risk" species?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Abiotic or Ecosystem Processes

2.13 What is the potential level of effect on abiotic or ecosystem processes?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Guidance

The alien species will have **No Effect** when there is no perceivable impact on abiotic or ecosystem processes within the assessment area.

A **Mild Effect** would result when the effects of the alien species are perceivable, but do not appear to negatively affect the species in the assessment area. For example, an alien species might affect noticeable alterations to soil nutrient availability, but there is no corresponding effect observed in the species in the assessment area.

A **Moderate Effect** would result when the effects of the alien species cause significant alteration to ecosystem processes (e.g. increases sedimentation rates along coastlines, reducing open water areas that are important for waterfowl)

A **Severe Effect** would result when the effects of the alien species cause major, possibly irreversible, alteration or disruption of ecosystem processes (e.g. the species

drains water from open water or wetland systems through rapid transpiration, making these areas more fire prone and unable to support native wetland species; species fixes nitrogen in the soil making soil unlikely to support certain native plants).

SECTION 3 - ECONOMIC EFFECTS

3.1 What will be the expected effects of the species on the crop industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

The crop industry has many areas from the farm gate to export destinations including crop production, export markets, etc. which all may be effected by a species. Crop production takes place under conditions where farmers rely on nature to provide certain essentials (soil, nutrients, rainfall) augmented by their own management practices regarding soil conservation, water conservation, fertilizer application and pesticide/herbicide use based on their understanding of environmental conditions. An alien species can disrupt this production system by crowding out crops (via direct smothery, allelopathy, or competition for light, nutrients and water), thereby reducing productivity in the absence of any remedial or preventative actions.

Guidance

Consider the expected effects of the species on the crop industry including:

- Direct impacts (e.g. reduced production, reduced export opportunities, markets, etc)
- Indirect impacts (e.g. increased cost of production due to additional equipment cleaning).

Farm profit margins vary according to natural subregions, soil zones, weather, crop prices and input costs. The inability to maintain expected profit margins due to the invasion of a species would represent a significant effect. Estimate crop production deviation from the 10-year average production.

The alien species will have **No Effect** when it does not affect crop production, yield or industry within the assessment area. A **Mild Effect** would result when the effects of the alien species causes an estimated decline in crop production of 15% or less within the assessment area. A **Moderate Effect** would result when the effects of the alien species causes an estimated decline in crop production between 15-25 % within the assessment area. A **Severe Effect** would result when the effects of the alien species causes an estimated decline in crop production over 25% within the assessment area.

3.2 What will be the expected effects of the species on the livestock industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

The livestock industry has many areas from the farm gate to export destination including livestock production, export markets, etc. which all may be effected by a species. Livestock production (including cattle, horses, bison, sheep, lama, deer, goat, pigs, poultry, and bees) takes place under conditions where farmers rely on nature (i.e. to provide soil, nutrients and rainfall to produce feed) and their own management practices (i.e. in the areas of soil and water conservation, purchased feed and animal care based on their understanding of environmental conditions, animal health and optimal production conditions). Species often disrupt this production system and reduce profit. Some plant species are toxic if ingested by livestock, crowd out feed crops or attach themselves to animal fur in large quantities (i.e. sheep, lamas) thereby becoming a nuisance and lowering the quality of the product (e.g. wool).

Guidance

Consider the expected impacts of the species on the livestock industry including:

- Direct impacts (e.g. reduced production, reduced export opportunities, markets, etc.)
- Indirect impacts (e.g. supplemental food needed)

The alien species will have **No Effect** when it does not affect the livestock industry within the assessment area. A **Mild Effect** would result when the effects of the alien species on livestock population is less than 2.5% animal loss year over year within the assessment area. A **Moderate Effect** would result when the effects of the alien species on livestock population ranges between 2.5% to 5% animal loss year over year within the assessment area. A **Severe Effect** would result when the effects of the alien species on livestock population expected changes are over 5% animal loss year over year within the assessment area.

3.3 What will be the expected effects of the species on the dairy farm industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

The dairy industry has many areas from the farm gate to export destination which include milk production, export markets, etc. which all may be impacted by an alien species. Dairy farmers rely on feed crops to feed their herds during Spring, Summer and Fall when the animals can be in the pasture. They also harvest some feed crops for storage and winter feeding. An alien plant species could crowd out feed crops making it necessary to purchase additional feed or it could have a negative effect on cattle health, if eaten, thereby impacting milk production and quality. All of the effects lead to a reduction in dairy farming net revenue and profitability.

Guidance

Consider the expected impacts of the species on the dairy industry including:

- Direct impacts (e.g. lower production, reduced export opportunities, markets, etc.)
- Indirect impacts (e.g. higher feed costs)

Milk production is supply-managed and the producers usually meet their designated quota. A negative impact by an alien species would lead to the industry producing under quota. Species may also cause a negative impact on the dairy industry if they increase production cost or reduce market value of the product in any of the following ways:

- Increased feed costs;
- Reduced market value due to reduced milk quality (e.g. taste)

The alien species will have **No Effect** if it does not affect milk production, feed costs or other aspects of the dairy industry within the assessment area. It has been suggested that deviations from the quota by more than 2% are unusual. A **Mild Effect** would result when the effects of the alien species on the dairy industry causes a decline in production within 2% of the quota. A **Moderate Effect** would result when the effects of the alien species is 2% to 5% below quotas. A **Severe Effect** would result when the effects of the alien species causes 5% or more quota shortfall.

3.4 What will be the expected effects of the species on the greenhouse industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

The greenhouse industry has many areas from the greenhouse to export destination which include production, export markets, etc. which may be effected by an alien species. The size of the Alberta greenhouse industry is estimated at 118.5 ha (293 acres), distributed among approximately 400 growers spread across central and southern Alberta. Major crops grown are vegetables, bedding plants, cut flowers, potted ornamentals, foliage plants and tree seedlings. The value of the industry is estimated to be about CDN $140 million with an investment of $260.00 million. The industry employs 1,450 full time and 3,100 part-time people. Weeds in greenhouses can compete with desirable crop plants for light, water and nutrients. They are unsightly and often harbor undesirable insects and diseases. Aquatic weeds can cause indirect impacts on greenhouse operations by affecting the industry's water supply. The latter risk may be limited where operations use ground water or municipal sources. Further information and expert contacts to help can be found at:

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp11211

Guidance

Consider the expected impacts of the species on the greenhouse industry including:

- Direct impacts (e.g. production, reduced export opportunities, markets, etc)
- Indirect impacts (e.g. whether it is known to harbor insects and/or diseases, or if it has the potential to affect water supply)

The alien species will have **No Effect** if it does not affect the greenhouse industry within the assessment area. A **Mild Effect** would result when the effects of the alien species cause tolerable disruptions in the functioning of the greenhouse operations (i.e. additional time and energy dealing with the management of the alien species). A **Moderate Effect** would result when the effects of the alien species cause unacceptable disruptions in the functioning of the greenhouse operations (i.e. substantial time and energy spent on management of alien species which causes a slight economic loss from the previous year). A **Severe Effect** would result when the effects of the alien species cause unacceptable disruptions in the critical or essential functioning of the greenhouse operations (i.e. a significant loss of time, energy, product and money due to an alien species).

3.5 What will be the expected effects of the species on the aquaculture industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

The aquaculture industry in Alberta produces about $10 million of product annually in small operations spread across the province but mainly in the Edmonton area and central and southern Alberta. Aquaculture is wholly dependent on a clean, safe water supply. Aquatic alien species are of concern to this industry because they cause direct mortality of desirable aquatic organisms, compete for space and food, cause an deterioration in water quality, or rapidly cover aquaculture gear, thereby increasing the costs to produce the intended species.

Additional information is located at the following link with expert contacts residing in Alberta Aquaculture Association and the Alberta Aquaculture Centre of Excellence.

http://www1.agric.gov.ab.ca/$department/newslett.nsf/all/aqua11443

Guidance

Consider the expected impacts of the species on aquaculture productivity including:

- Direct impacts of the species (e.g., predator, competitor for food or space, or negative impacts on water quality);
- Indirect impacts (e.g., effects on aquaculture equipment and infrastructure);

The alien species will have **No Effect** if it does not affect the aquaculture industry within the assessment area. A **Mild Effect** would result when the effects of the alien species result in negative publicity to the aquaculture industry and reduces market potential in parts of the province. A **Moderate Effect** would result when the effects of the alien species result in some fish losses and infrastructure modifications to prevent further losses in the future. There are increased disease surveillance requirements to maintain market potential. A **Severe Effect** would result when the effects of the alien species result in the loss or quarantine of all fish being reared and significant infrastructure improvements to maintain aquaculture operation at the site. Markets would be lost because of the potential for transporting aquatic invasive species to potential market areas.

3.6 What will be the expected effects of the species on the commercial and recreational fishing industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Typically Alberta's commercial fisheries land about 1.8-2.3 million tones (live weight) with a gross value of $2.25-3 million. Whitefish account for 85% or more of the landings and value. Current management plans involve a license buy-out program that has led to about 160-170 licensed commercial fishermen currently active. Commercial fishing activity in Alberta is concentrated mainly in lakes in the North and to a lesser extent in small lakes in the irrigation districts in the South.

Sport fishing is a valuable social and economic recreational sport in Alberta. In 2005, there was an estimated 300,000 anglers who spent a total of 3.3 million days fishing in Alberta. Recreational fishing contributes over $440 million to the provincial economy while harvesting millions of sport fish from a variety of lakes.

Alien aquatic animal species may have negative effects on this industry by competing for food and other resources and/or by predation on the desirable fish species. Other alien aquatic organisms negatively impact fisheries by changing the structure of aquatic communities and ecosystem functions of the lakes, altering chemical and physical properties of the lake water, and/or affecting fish health. [Additional Information can be found at:
http://www.srd.gov.ab.ca/fishwildlife/fishingalberta/commercialfishing.aspx ; expert contacts can be found within Alberta Sustainable Resource Development and the Alberta Commercial Fishermen's Association]

Guidance

Consider the expected impacts of the species on the commercial and recreational fishing industry including:

- Direct impacts (e.g. reduced fish production, reduced angler markets, etc.)
- Indirect impacts (e.g. tourism benefits, fishing equipment sales, increased production costs due to the requirements to clean fisheries equipment of the AS etc)

The alien species will have **No Effect** if it does not affect the commercial and recreational fishing industry within the assessment area. A **Mild Effect** would result when the effects of the alien species cause a reduction of an opportunity to conduct recreational or commercial fishing at one or few waters, or incur cost increases that

reduce the economic viability of at least one commercial fishery. A **Moderate Effect** would result when the effects of the alien species cause a complete loss of opportunity to conduct recreational or commercial fishing at one or few waters, or incur cost increases that reduce the economic viability of more than one commercial fishery. A **Severe Effect** would result when the effects of the alien species cause a loss of complete opportunity to conduct recreational or commercial fishing activities at many waters, or reduce the economic viability of many commercial fisheries or render them unviable.

3.7 What will be the expected effects of the species on the food processing industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

The food processing industry has many areas which may be impacted by alien species. These include processing facilities, food safety and quality, and export markets. A reduction in primary production (of crops, livestock, dairy, greenhouse products, aquaculture or commercial fishing) could lead to reductions in food processing activities. Since processing is a separate industry, it is necessary to consider alien species related risks to it separately. For additional information contact the Alberta Food Processors Association (http://www.afpa.com/).

Guidance

Consider the expected impacts of the species on the processing industry including:

- Direct impacts (e.g. primary production level)
- Indirect impacts (e.g. avoiding specific brands due to invasive species)

The alien species will have **No Effect** when it does not affect primary production within the assessment area. A **Mild Effect** would result when the effects of the alien species has a low risk to primary production therefore, the related risk to the food processing industry is low. A **Moderate Effect** would result when the effects of the alien species has a moderate risk to primary production therefore, the related risk to the food processing industry is the same. A **Severe Effect** would result when the effects of the alien species has a high risk to the food processing industry therefore, the related risk will depend on the proportion of primary product used by the food processing plant.

3.8 What will be the potential risk to the forestry industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

The forestry industry has many areas from the cutblock to export destination which include production, export markets, etc. which may be impacted by an alien species. The economic viability of forestry production is based on maintaining the annual allowable cut (AAC) for their particular harvest areas. Some variation in AAC is normal because of changes to land use practices, fires and existing pests reducing yields and silviculture activities increasing production. Since AAC reflects the mix of tree species and the productivity of a fixed land base, reductions in AAC can be effectively measured in terms of the amount of the forest land base that would be taken out of production over the long run by an alien species. Some species could lead to a dramatic decline in the AAC: in British Columbia, for example, it has been estimated that the pine beetle will lead to a 25% cut in the AAC from pre-beetle levels to a 50% cut from current levels.

Guidance

For Alberta, historical variations in the AAC are on the order of four per cent. Note that most of the impact on AAC will result from the negative effects on the regeneration of the forest after the cut has occurred. Two to three major forest companies in Alberta (in case of the species already present in the region/province) or other provinces/countries (in case of a species not yet present in AB) should be contacted for their estimate on potential threat of a specific species to forest regeneration (Toso Bozic, 2008). Any alien species that would result in the long-term reduction of AAC outside this normal range of variability would be a threat to the continued viability of forest operations at current levels and risk should be assessed accordingly.

The alien species will have **No Effect** on forestry production when reduction falls within the normal variation of +/-4% within the assessment area. A **Mild Effect** would result when the effects of the alien species causes a reduction of an additional 1 to 2% to forestry production within the assessment area. A **Moderate Effect** would result when the effects of the alien species causes a reduction of an additional 3 to 4% to forestry production within the assessment area. A **Severe Effect** would result when the effects of the alien species causes a reduction of 5% and above to forestry production within the assessment area (Neil Shelly, 2007).

3.9 What will be the potential risk to the non-timber forest product industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Typically, Non-timber Forest Products (NTFP) include: edible products (e.g. wild mushrooms and berries); floral and greenery products (e.g. mosses and boughs); medicinal and pharmaceutical products (e.g. herbs and essential oils); whole plant extraction (e.g. landscaping transplants); and craft products (e.g. willow, grasses, cones and bark). Although not well developed in a commercial market sense, they are seen as potential drivers of economic development and income for Aboriginal Peoples in rural or remote communities throughout the boreal forest area of Alberta. Considering the range of possible products, an alien species could expose these uses to considerable risk of reduction or loss according to the plants or environmental conditions that support the NTFP.

Guidance

Consider the potential of the species to affect non-timber forestry product industry including:

- Direct impacts (e.g. reduced product, reduced economic development for northern communities)
- Indirect impacts (e.g. reduced income, sales and clients if you cannot supply the demand)

It may be difficult to obtain systematic data on this industry owing to its fragmented structure with many small and part-time participants. Using information from local informants, assessing risk from an AS will require the application of good judgment based on the best available information on the various segments of this industry.

The alien species will have **No Effect** when it does not affect non-timber forest production within the assessment area. A **Mild Effect** would result when the effects of the alien species reduce the availability of common or abundant non-timber forest products. A **Moderate Effect** would result when the effects of the alien species reduce the availability of rare or essential non-timber forest products. A **Severe Effect** would result when the effects of the alien species eliminates non-timber forest products that are drivers of economic development.

3.10 What will be the expected impacts on the tourism industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Alien species can impact recreational tourism activities such as fishing, hunting, hiking, wildlife viewing, and water-based recreation. They can negatively affect a wide array of environmental attributes that are important to recreation like water quality and quantity, plant and animal diversity, and species abundance. Eurasian Watermilfoil (*Myriophyllum spicatum*), for example, is present in BC. This aquatic perennial forms large floating mats preventing light penetration making fishing and boating difficult. Boating is the primary mechanism of spreading this species as plant fragmentation can attach to the boat or trailer and be transported elsewhere. In any event, tourists are known to be cautious and could be diverted from Alberta or local areas within Alberta based on perceptions about an alien species.

Guidance

Tourism as a mix of food service, accommodation, transportation, sightseeing, commercially supplied recreation activities and other goods and services that tourists purchase from for-profit businesses (non-commercial recreation activities are included under Social Impacts). Typical indicators used to gauge tourism industry activity include number of visitors, number of visitor days (number of visitors times days stayed) and spending. To estimate the impacts on tourism one must also consider: the nature of the species, predicted effects of contact and the extent of its invasion (local areas versus the whole province).

Consider the expected impacts of the species on the tourism industry including:

- Direct effect of the species on tourism visits (e.g., beach closures due to algal blooms, etc.)
- Indirect effect of the species on tourism visits (i.e. increased costs due to boat engines and steering equipment being jammed and ruined with non-native plants, etc.)

The alien species will have **No Effect** when it does not affect the tourism industry. A **Mild Effect** would result when the effects of the alien species has no appreciable impact on the tourism activities or experiences; there is little if any recognition by the visitor that the invasive species is of concern. For example, dandelion or oxeye daisy infestations. A **Moderate Effect** would result when the effects of the alien species negatively impacts a popular visitor activity but does not eliminate it; the quality of the experience is reduced to the degree that visitors are aware of the issue. For example, a

thistle outbreak encroaching a trail making the hiking experience unpleasant. A **Severe Effect** would result when the effects of the alien species severely limits or curtails a popular visitor activity impacting the experience negatively to the extent that visitor satisfaction is significantly reduced. For example, a mountain pine beetle infestation results in the removal of majority of the mature trees from a tourism destination community significantly reducing the ambiance of the location.

3.11 What will be the expected effects on the energy industry?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

The energy industry has several sub-sectors including oil and gas, hydroelectricity, thermal electricity and wind power. Without limiting full consideration of the aforementioned, it seems likely that hydroelectricity, thermal electricity and wind power would have a greater vulnerability to impacts from alien species. For example, an aquatic plant could interfere with water flow or foul intake pipes while an aquatic animal such as, the zebra mussel could clog water intakes, or air borne species could interfere with wind power generators. Companies may be required to clean their equipment before and after going onto a site to reduce seed transfer by mud on tires.

Guidance

Experience from other jurisdictions where the species in question has been a factor could provide useful initial indications of possible risks to the assessment area. Will the presence of the species diminish the sustainability of any sectors of the energy industry?

Consider the expected impacts of the species on the energy sector (i.e. Oil & Gas, Mine operations, etc.) including:

- Direct impact of the species on energy operations (e.g., interference with water flow and foul intake pipes)
- Indirect impact on energy production (i.e. increased production costs and delays due to the reclamation certification requirements).

The alien species will have **No Effect** when it does not affect the energy industry within the assessment area. A **Mild Effect** would result when the effects of the alien species cause a tolerable impact on the energy industry. A **Moderate Effect** would result when the effects of the alien species cause an unacceptable impact on the energy industry but does not significantly diminish sustainability. A **Severe Effect** would result when the effects of the alien species cause an unacceptable impact on the energy industry and threatens sustainability.

3.12 What will be the expected effects of the species on infrastructure?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Infrastructure is typically defined as the basic facilities, services, and installations needed for the functioning of a community or society such as, transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons. Water supply systems have been the most vulnerable to the effects of alien species therefore, concentrating on possible impacts on water supply is appropriate while remaining alert to other possible impacts.

Guidance

Consider the potential impacts of the species to infrastructure:

- Direct effects (e.g. operation problems for municipal water supplies)
- Indirect effects (e.g. rise in taxes to offset increase infrastructure costs)

We have seen the economic impacts of invasive water species such as, Zebra Mussels and Hydilla ability to clog water intake pipes. The level of impact would presumably increase with the amount of disruption to normal operations.

The alien species will have **No Effect** when it does not affect the infrastructure of a community or society within the assessment area. A **Mild Effect** would result when the effects of the alien species cause tolerable disruptions to the infrastructure and functioning of a community or society. A **Moderate Effect** would result when the effects of the alien species cause unacceptable disruptions to the infrastructure and the functioning of a community or society. A **Severe Effect** would result when the effects of the alien species cause unacceptable disruptions to infrastructure and the critical or essential functioning of a community or society.

3.13 What will be the expected effects on the health care industry?

0 = No Effect
1 = Mild Effect
2 = Moderate Effect
3 = Severe Effect
3 = Unknown

Rationale

An alien species may have a major effect on human health through one or more exposure pathways (e.g., inhalation of pollen, ingestion of food (poisonous plant/fish), skin contact (bites from insects like the fire ant; or water ingestion)). Contact with some species may require substantial medical treatment costs to reverse their effects or cure resultant medical conditions. Other species may cause long-term (or short-term), non-reversible effects including death. In both cases, there may be substantial medical costs during the period of sickness. These risks must be evaluated.

Guidance

Consider the expected impacts of the species on the health care industry including:

- Direct effects (e.g. allergic responses, poisoning, death, etc.)
- Indirect effects (e.g. health cost from increased exposure to pesticides, or herbicides used to manage the alien species, etc.)

The alien species will have **No Effect** when it does not affect the health care industry. A **Mild Effect** would result when the effects of the alien species cause slight physical discomfort or other threatening symptoms that may require medical attention (e.g. doctor visit) with a low cost to the health care system. A **Moderate Effect** would result when the effects of the alien species cause allergic responses such as, impaired breathing, and other medical conditions that would require medical attention with the possibility of a shot-term stay at a hospital causing an additional cost to the health care system. A **Severe Effect** would result when the effects of the alien species cause potentially life threatening responses such as poisoning, or a severe allergic reaction (i.e. anaphylactic shock) requiring medical attention with the potential of long-term hospital stays or other medical requirements putting a significant additional cost on the healthcare system.

3.14 What will be the expected effects on Alberta's exports?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Concern about the impacts of a species, or more specifically, concern about transmission of the species from Alberta to other countries may lead those countries to ban imports of Alberta products. The recent response to the cases of BSE in Canadian cattle, although not an invasive alien species, it is nevertheless a good example of how countries can react. Examining what the response has been to a particular species in other jurisdictions would be the appropriate approach to assess the risk the species poses for Alberta exports. If this is different, it concerns the risk of losing markets and market share for Alberta export products rather than the risks related to conditions of production, which was the concern in the previous questions.

Guidance

Consider the potential impacts of the species to Alberta's export industry:

- Direct effects
- Indirect effects (e.g. loss of jobs)

The operational risk is defined by the extent to which species establishment induces some of Canada's trading partners to embargo exports of Alberta produced products (i.e., crops, livestock, processed food products, timber and non-timber forest products, others)? Consultation with Government of Canada trade officials, particularly on the experience with the species in question in other jurisdictions, will be the way to determine the risk level.

The alien species will have **No Effect** when it has no effect on Alberta's exports. A **Mild Effect** would result when the effects of the alien species result in increased scrutiny of Albertan products resulting in more stringent inspection processes and/or increased delays at the border causing increased shipping, transportation and time costs but does not reduce demand. A **Moderate Effect** would result when the effects of the alien species result in decreases in the demand for Albertan products. Demand for affected products/goods associated with the particular invasive is *moderately* reduced resulting in quantifiable economic losses in addition to the mild impacts. A **Severe Effect** would result when the effects of the alien species eliminates the demand for Albertan product(s) associated with the particular invasive species and/or results in the border being closed to the product(s) for an extended period of time resulting in large economic losses to Albertan producers (e.g. Alberta/US border closed to beef shipments during the cases of BSE).

SECTION 4 - SOCIAL EFFECTS

4.1 What will be the expected effects on human health and well-being?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Good health is generally associated with a high degree of satisfaction and enjoyment of life. Humans are exposed to many substances throughout the course of their lifetime affecting their health and well-being, some positively and some negatively. Therefore, the risk of exposure to an alien species and its potential negative effects on health must be considered for overall human quality of life.

A species may have direct or indirect impacts on human health and well-being. Direct impacts result from exposure to the species (e.g. ingestion, skin exposure or inhalation of pollen). An alien species may contain substances or structures that can negatively impact the health and well-being of individuals. Indirect impacts on health are from environmental conditions created by or related to the species and not from exposure to the species itself (i.e. exposure to pesticides used to control the species).

Guidance

Does the species contain structures (i.e. thorns) that may cause physical discomfort (i.e. scratches or rashes) to human beings? Is the species an allergen? Does it contain allergens that may cause allergic reactions in humans? Will exposure to pesticides and other tools used to manage, control or eliminate the species impact human health? What level of impact will the species have on human health?

A **Mild Effect** would result when the effects of the alien species cause slight physical discomfort such as scratches, mild rashes, sneezing and other non-life threatening symptoms that would not require medical attention. A **Moderate Effect** would result when the effects of the alien species cause allergic responses such as, impaired breathing, and other medical conditions (e.g., elevated blood pressure) that may require medical attention. A **Severe Effect** would result when the effects of the alien species cause potentially life threatening responses such as poisoning, or a severe allergic reaction (i.e. anaphylactic shock). Severe impacts would require medical attention, potential long-term hospital stays, lasting side effects or death of an individual.

4.2 What will be the expected effects on recreation activities?

0 = No Effect
1 = Mild Effect
2 = Moderate Effect
3 = Severe Effect
3 = Unknown

Rationale

Recreational values are any activity in which one engages in for relaxation, amusement or pleasurable exercise. Alien species can impact recreational activities by impeding or preventing them. For example, they can create physical barriers (i.e. spines, thorns, burrs), dense thickets or smother habitat so its recreational value is lost. Stinging foreign species can make such activities more difficult while being less enjoyable. Aquatic alien species can limit access, impair activities and cause additional management needs such as equipment cleaning.

Guidance

Does the species have structures that impede or prevent recreational activity (e.g. thorns, burrs)? Does the species have a growth habit that impedes or prevents recreational activity (i.e. forms mats on lakes, grows into dense thickets)? Will the presence of the species result in avoidance of recreational activity (i.e. unpleasant odors, biting flies)? What will be the expected direct impact of the species on recreation activities (i.e. minor inconvenience to prohibition of access to activities)? What will be the expected indirect impact of the species on recreation activities (i.e. negative impacts on the ecosystem diminishing the quality/quantity of the experience)? Will the presence of the species result in avoidance of recreational activities? Will the presence of the species result in access limitations to the recreational area? Will the presence of the species result in increased management needs (e.g. cleaning equipment)?

A **mild effect** would result when the effects of the alien species interferes with a person's enjoyment of that recreational activity. This intrusion may cause some annoyance to the recreational user however; one can still proceed with the activity. For example, while quading burrs attach to your clothing. A **moderate effect** would result when the effects of the alien species impedes with a persons enjoyment of the recreational activity. The alien species causes additional time and energy by putting up barriers which takes away from the enjoyment of the activity. For example, a lake infested with zebra mussels. One has to spend additional investment of time and energy cleaning the boats, and de-clogging pipes and motors. A **severe effect** would result when the effects of the alien species diminishes or hinders a person's ability to partake or enjoy themselves in the recreational activity. For example, Kudzu is an invasive vine which suppresses and kills other plants altering the landscape. This would limit one's ability to hike, view wildlife or flowers.

4.3 What will be the expected effects on aesthetic values?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Aesthetic values refer to an area, scenery, or viewscapes of importance for their presentation of native species and water features, or some combination of these with unique topographic features. An aquatic species can create a societal impact by increasing human inconvenience or discomfort by displacing native species, reducing water clarity, increasing foul odors or changing the use patterns of the area. Eurasian watermilfoil (Myriophyllum spicatum L.), for example, is an aggressive water plant that can clog lakes and rivers making it difficult to boat or swim. Once it invades, there is currently no way to get rid of it.

Guidance

To what extent will the species lead to a loss in aesthetic values (excluding the urban environment)? Will the species lead to decreased rural property values? Will the species lead to a degradation of scenic values in a parks landscape? Public response to the effects of a species could provide an indicator through public opinion surveys or the number of calls to hot lines or complaint lines. However, these indicators are not likely to be available at the time this tool is being applied, (i.e., early in the invasion process). So, reviewing the types and extent of impacts associated with the particular species in neighbouring area or jurisdictions is likely to be a better early indicator of impacts within the assessment area.

Note: Exclude the urban environment when considering this question – covered in the following question that addresses the urban environment.

A **mild effect** would result when the effects of the alien species begins to alter the aesthetic value of the landscape. However, it is clear that the aesthetic value is still present. For example, if dandelions were to develop on a landscape. The native species are still present; however, the aesthetic value has been reduced. A **moderate effect** would result when the effects of the alien species begins to modify the aesthetic value of the landscape. A **severe effect** would result when the effects of the alien species alters the aesthetic value of the landscape so that it is no longer recognizable. For example, Kudzu suppresses and kills other plants, including tree seedlings and native plants. It can grow several metres a week in all directions covering most everything in its path, and can lead to nitrogen build up in rivers and lakes.

4.4 What will be the expected effects on the urban environment?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Urban ambiance refers to a mixture of urban features including healthy lawns, tree cover along streets, urban wetlands, green areas and parks. These features are regarded as important contributors to the quality of urban life. New weeds invading lawns and gardens and/or the overgrowth of vegetation in wetlands and watercourses from alien species (i.e. Chinese Tallow or Hydrilla) could result in a diminished quality of life in urban areas and loss of homeowner satisfaction.

Guidance

To what extent will the alien species lead to a decline in the quality of urban environments? Will the decline in the quality of the urban environment lead to decreased property values?

A **mild effect** would result when the effects of the alien species are present on the urban landscape in a visible manner but do not significantly interfere with or impact the overall ambiance of the urban environment. A **moderate effect** would result when the effects of the alien species are present on the urban landscape to such an extent that they reduce the overall quality and/or quantity of urban ambiance but do not eliminate it altogether. For example, as a result of the species, there are less green spaces to enjoy but other green spaces still exist in the area. A **severe effect** would result when the effects of the alien species reach a level where they dramatically alter the composition of the urban environment; eliminating the ambiance of the area and/or decreasing property value.

4.5 To what extent will the species decrease scientific research opportunities?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

The risk to be considered is whether or not an alien species may disrupt the environmental conditions under which existing or planned scientific research was expected to take place. Although one might think of an invasion of an alien species as a research opportunity, this kind of research is considered a necessity after the fact, rather than an “opportunity” for the purpose of this risk assessment. If the environment is altered, then the validity of the trial may be questioned.

Guidance

To what extent will the alien species decrease scientific research possibilities? Will the alien species disrupt environmental conditions for planned or existing research opportunities? Will the alien species replace/eliminate a desired species for a planned or existing research opportunity? What level of impact will the alien species have on the research opportunity?

No effect would result when the alien species benefits from recent disturbances but does not compete well with native species (i.e. Shepherd’s Purse). A **mild effect** would result when the effects of the alien species negatively impacts one or a few native species. A **moderate effect** would result when the effects of the alien species negatively impacts an ecological community. A **severe effect** would result when the effects of the alien species negatively impacts an ecological process at a landscape scale. For example, salt cedar alters the hydrological processes along a watercourse.

4.6 What will be the expected effects of the species on places of traditional value or cultural value?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Most cultures have places of cultural significance based on their traditions. These places may include hunting grounds and areas used for sacred or ceremonial purposes such as lakes, streams, trails or mountains. It would also include terrestrial and aquatic species specifically valued and used by groups in society within a specific cultural context, for example, an aboriginal community. Alien species may negatively impact these areas by displacing desirable species used for food or religious ceremonies therefore, causing changes to the landscape. These areas then could not be used for their traditional purposes because of the loss of features that were important for the conduct of ceremonies or food gathering potentially leading to a loss of traditions and values within that culture or community.

This is separate from existence, bequest and option values discussed in section 4.10 that covers non-use or passive use values.

Guidance

To what extent will the species result in reduced or lost cultural features or habitats? Would the presence of this species reduce the enjoyment of traditionally and culturally valued places? What extent would cultural practices have to be modified? What level of impact would the species have on places of traditional or cultural value? This impact could range from small-scale impacts affecting a local fishing area or ceremonial area, to large-scale impacts affecting national or provincial parks, protected areas, or areas of traditional activity for aboriginal people.

A **mild effect** would result when the effects of the alien species interferes with the traditional or cultural features or habitats but does not require cultural practices to be modified and/or does not decrease the enjoyment of traditionally and culturally valued places. A **moderate effect** would result when the effects of the alien species interfere with the traditional or cultural features or habitats in such a way that traditional or cultural practices need to be modified or changed in order to continue participating in this area. A **severe effect** would result when the effects of the alien species render the area unusable for traditional or cultural purposes.

4.7 To what extent will the species lead to a reduced or lost food supplies (including fish and game) traditionally available from the assessment area?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

From a human perspective, traditional habitat refers to an area used for hunting and gathering of wild or country food for personal or group consumption rather than for sale to third parties (i.e. non-timber forest products). Although this question would be less important today than historically, it is included for completeness. Invasive plants similar to kudzu, Japanese honeysuckle, Chinese tallow, Hydrilla, and Eurasian watermilfoil could have substantial impacts on traditional habitat and the food supplies in those habitats.

Direct impacts on traditional food supplies can also result from alien species such as, parasites, predators and diseases on native fish species or other aquatic food supplies.

Guidance

To what extent will the species lead to reduced or lost traditional habitats? To what extent will the species lead to reduced or lost traditional food supplies?

A review of the experience elsewhere with an alien species should provide some knowledge of possible impacts. The extent of the potential impact in Alberta can be assessed through consultation with aboriginal groups in areas to determine if traditional habitat still plays a significant role in the food supply.

A **mild effect** would result when the effects of the alien species are an inconvenience in accessing traditional habitats and/or food supplies but do not reduce the ability to continue to hunt or gather. A **moderate effect** would result when the effects of the alien species are able to influence the provision of traditional areas and/or food supplies by reducing the availability and/or increasing efforts necessary to procure them. Traditional habitat and/or food supplies are still present but in declining quantity and/or availability. A **severe effect** would result when the effects of the alien species eliminate traditional habitats and/or food supplies from the area or reduce the availability to such an extent that users will choose to go elsewhere for their hunting and gathering.

4.8 To what extent will the species decrease nature-based educational opportunities?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Natural areas are used for educational purposes by school groups, adult education groups and others. The Environmental Education and Interpretative programs offered by National, Provincial and other parks are also educational undertakings. All of these programs are based on the healthy natural landscapes (positive messages are considered much stronger educational tool than the negative ones – i.e., giving examples of invasions). An alien species can diminish educational/interpretive programming by displacing native species (one species, e.g., Eurasian water milfoil, or a suite of species), making access to the educational locations difficult (e.g., Canada thistle), or causing allergic responses to educators/interpreters or those being educated, (e.g., ragweed). Although one might think of an invasion of alien species as an educational opportunity, this kind of education is considered a necessity after the fact, rather than an “opportunity” for the purpose of this risk assessment.

Guidance

To what extent will the alien species result in reduced or lost education opportunities? Care should be taken to assess the extent to which these impacts are specifically on educational programs and not already captured in other social impacts; that is, are they truly independent impacts? This could range from small-scale impacts affecting a local nature reserve to moderate scale impacts affecting a large national or provincial park, or large-scale impacts spreading across national or provincial parks and protected areas across the province.

No effect would result when the alien species benefits from recent disturbances but does not compete well with native species (e.g. Shepherd's Purse). A **mild effect** would result when the effects of the alien species often dominate lawns in facility areas and occasionally intersperse into native vegetation, but rarely change the composition and structure of natural community, would have a low impact (e.g., dandelions). A **moderate effect** would result when the effects of the alien species disrupts accessing of educational locations would have a moderate impact (e.g., Canada thistle surrounding wetlands). A **severe effect** would result when the effects of the alien species causes a loss of educational opportunity within the study area (e.g., Purple loosestrife may cause the exclusion of all suitable wetlands from wetlands programming).

4.9 Will the species affect the perception that something of natural value will continue to exist?

0 = No effect
1 = Mild effect
2 = Moderate effect
3 = Severe effect
3 = Unknown

Rationale

Passive values refer to aspects of the environment which people value even though they do not currently use them or experience them directly. They value them because they exist; because they want to be able to pass them on to future generations, or because they place a value on retaining options for possible future use (by humans), respectively. Referred to collectively as Passive Use values, they can be considered to include aspects such as Wilderness Protection, Biodiversity (e.g. native plants, old growth forests, pristine lakes) and Valued Natural Features that people value on an existence, bequest or option basis and not because they are currently used or experienced directly. Any current use or enjoyment should be captured in one or more of the other economic or social categories.

Guidance

To what extent will the species cause a reduced wilderness protection that will affect Passive Use value? To what extent will the species lead to reduced species preservation and a loss in biodiversity that will affect Passive Use value? To what extent will the species result in reduced or lost specific natural features that will affect Passive Use value? These could be small-scale impacts affecting a small-scale local site, to moderate-scale impacts affecting national or provincial parks and protected areas, or large-scale impacts affecting the whole province.

A **mild effect** would result when the effects of the alien species begin to modify the area in such a way that concern is raised over the ability of the area to provide aspects of the environment which, while not being used now, may be used in the future. A **moderate effect** would result when the effects of the alien species are affecting the ability of the assessment area to continue to provide the environmental aspects which are currently valued as passive use. A **severe effect** would result when the effects of the alien species drastically reduces the potential of or eliminates one or more items which contribute to passive use values in the area of assessment. For example, this would occur if the alien species eliminated the potential for future biodiversity of the area.

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6.0 GLOSSARY

Alien species: species of plants, animals (including fish), and micro-organisms introduced by human action outside their natural past or present distribution. (Also known as exotics, or specified as being foreign or non-native.)

Allelopathy- is the science of any processes involving secondary metabolities produced by plants, algae, bacteria, coral and fungi that influence the growth and development of agricultural and biological systems. These systems are an important factor in species distribution and abundance.

Anthropogenic mechanisms: human-mediated processes; those which would not occur in the absence of human action.

Asexual Reproduction: the formation of a new individual from parent cells without the formation of meiosis, gamete formation or fertilization for example, fission, spores or budding. This is well suited for colonizing new habitats as a single individual can establish the new population.

Biodiversity: variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Containment: the application of measures in and around an infested area to prevent the spread of an invasive species beyond a defined area.

Control: the treatment that prevents the pest from spreading, reproducing and/or kill an unwanted organism and/or disruption the pest or host life cycle.

Control Methods

- **Behavioral Control:** the use of control practices to suppress a pest population by taking advantage of a pest's natural behavior.
- **Biological Control:** the use of a living organism to control or kill a pest.
- **Chemical Control:** the use of synthesized or naturally derived products to control an unwanted organism.
- **Cultural Control:** the use of human control practices by creating a less favorable environment without the direct application machinery.
- **Mechanical/Physical Control:** the use of equipment/devices to physically alter an unwanted organism or through manipulation of environmental factors (e.g. temperature) to control an unwanted organism.

Eradication: application of measures to eliminate an invasive alien species from a definded area**.**

Fecundity: the capacity to produce offspring; a measure of fertility (e.g. the number of eggs or seeds produced by an organism).

Hazard identification: the process of identifying the pathogenic agents which could potentially be introduced in the commodity considered for importation.

Hybrid: the offspring resulting from cross-breeding of different plants or animals.

Introduced species- see “alien species”.

Invasive species: a harmful alien species whose introduction or spread threatens the environment, the economy, or society, including human health.

Invasion Pathways: natural, anthropogenic or a combination of both in which a species can enter an area.

Risk: the uncertainty that surrounds future events and outcomes, a function of the probability (chance, likelihood) of an adverse or unwanted event, and the severity or magnitude of the consequences of that event.

Risk analysis: a systematic approach to decision making regarding the use of alien species through hazard identification, risk assessment, risk management, and risk communication.

Risk assessment: the evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences, where economic consequences are interpreted to include environmental consequences.

Risk communication: the interactive exchange of information on risk among risk assessors, risk managers and other interested parties.

Risk indicator: categories of criteria used to measure risk.

Risk management: the evaluation and selection of options to reduce the risk of introduction and spread of a pest.

Risk communication: the interactive exchange of information on risk among risk assessors, risk managers and other interested parties.

Species: A group of interbreeding organisms which differ from and are reproductively isolated from other such groups.

Unintentional Introductions: all other introductions which are not intentional.

Vector: means by which species from a source populations follows a pathway to a new destination.