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Guidelines for the use of the Decision Support System “Calculating Wilding Spread Risk From New Plantings”

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REPORT INFORMATION SHEET

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Front-cover picture: well sheltered Douglas-fir stand with good growth potential, Northern Canterbury (TSH Paul)

GUIDELINES FOR THE USE OF THE DECISION SUPPORT SYSTEM "CALCULATING WILDING SPREAD RISK FROM NEW PLANTINGS"

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June 2015

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Guidelines

These guidelines are intended to give individual landowners, consultants and planners the ability to carry out an initial assessment of wilding spread risk for new afforestation projects. The assessment uses a Decision Support System (DSS) known as the Wilding Spread Risk Calculator. Users will be able to assess wilding spread risk in a transparent, consistent and repeatable manner using the step by step description and examples.

The guidelines should be read in association with the Wilding Spread Risk calculator. The Wilding Spread Risk Calculator is comprised of two calculators, one for new plantings (DSS1) and one for the assessment of the risk for a site to be invaded by wilding conifers (DSS2). These guidelines are specifically for the calculation of spread risk associated with new plantings (DSS1). The current version of the Calculator was released in June 2012 (DSS 1 - version _07011) and can be downloaded from www.wildingconifers.org.nz, and a copy is attached at Appendix One.

Outline of the decision support system “Calculating Wilding Spread Risk From New Plantings” (DSS1)

Wilding conifer spread has been researched over a number of decades by Scion (NZ Forest Research Institute Ltd; a Crown Research Institute; Ledgard, et al., 1999) and other organisations. The Decision Support System draws on this extensive research. The current version of the Decision Support System is a result of continual improvements and modifications. As the DSS is an evolving tool, it will be updated periodically on the basis of new research. It is envisaged that the guidelines will be updated in line with future revisions of the DSS.

The assessment of wilding spread risk is based on five indicators that play a dominant role in seed dispersal, wilding establishment and survival:

- **Spread vigour** of tree species (Indicator 1)
- **Palatability** of tree species to stock (Indicator 2)
- **Topographic siting or “placement” of the afforestation site** (Indicator 3)
- **Land use characteristics of seed receiving land** (Indicator 4)
- **Present vegetation of seed receiving land** (Indicator 5)

Points are assigned to each of the five indicators when assessing a proposed afforestation site. When the points are summarised, this provides a total score that ranks the proposed planting according to risk classes/levels. The total score for a site indicates the risk level of spread and establishment of wilding conifers from a new afforestation site. The flowchart provides an overview of the calculation process (Figure 1).
A number of stop/go exceptions are part of the calculations. These exceptions are related to the scoring of spread vigour of a species (growth), land-use and vegetation cover. Scoring zero for one of these indicators results in a total score of zero for the assessed combination of site and receiving area. For example where:

- **Spread vigour of tree** = 0; or
- downwind **land use** = 0; or
- downwind **vegetation cover** = 0

the total score becomes zero for the assessed combination of site and receiving area.

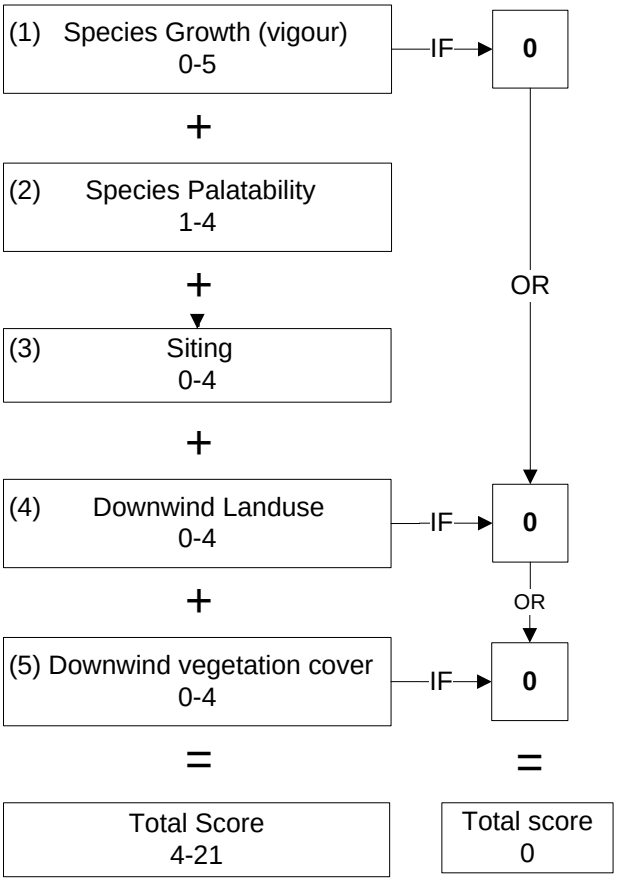


Figure 1. Scoring process for a single assessment of a proposed afforestation site, including the scoring of the seed receiving land downwind.

Assessing the risk of wilding spread is the first step for any afforestation proposal. Where a risk of spread exists, the owner or manager needs to plan for future monitoring and control of wildings. Even with a total score of 0 a small risk of unwanted spread cannot be fully excluded and 100% avoided. However, a small risk can be acceptable as long as owners and managers of new afforestation projects make a long term commitment to manage fringe spread and remove outlier trees before coning age.

The assessment in its individual steps

Indicator One: Species Growth (Spreading vigour)

The choice of species to be planted on a site is a major factor determining the risk of conifer spread from the new planting in the future, due to the species seed and coning characteristics. Seed weight and wing size, as well as timing and intensity of cone production, timing of seed release and cone placement (Figure 2) are species-specific traits that influence the risk of wilding spread.

Figure 2. Cone placement of radiata pine (left) and Douglas-fir (right). Seed from cones positioned on the periphery of crowns are easier dispersed.

An assessment should be carried out for each species that will be planted at each proposed planting site (example Figure 3). It might be necessary to assess a larger afforestation project multiple times for all species that will be present on an afforestation site. Evidence of the tree species a site will be afforested with might be provided by planting stock-order or nursery pick-up ticket. Such evidence might be called for by the local council as part of a consent process or to confirm the status of a permitted activity.

Figure 3. A range of species with different vigour are planted on this site (cypress in foreground, scores 1; Douglas-fir –middle, scores 4; lawsons-cypress in the back, scores 1). For each part with a different species a risk score calculation is necessary.

The range of species in the wilding spread risk calculator also includes species which are highly unlikely to be planted nowadays such as mountain pine (*P.uncinata/mugo*) or those that are listed in regional pest management plans and are not allowed to be intentionally planted or seeded such as lodgepole pine (*P.contorta*)[1]. Radiata pine (*Pinus radiata*) and its various hybrids (e.g. *Pinus radiata x attenuata*) and Douglas-fir (*Pseudotsuga menziesii*) are the tree species expected to dominate new afforestation in the near future.

If the species planted scores zero (for a particular part of planting or if single species planting) there is no need to proceed further with the calculator for this part of the afforestation proposal.

Considerations specific to Douglas-fir

The cone and seed production of Douglas-fir can vary greatly with climatic conditions and sites. Coning is significantly less in moister (and often warmer) parts of New Zealand.

Figure 4: High coning intensity for a 30 year old Douglas-fir stand at a summer drought site.

The risk calculator takes this into account by including a variation to score Douglas-fir lower in areas that are moist and less affected by “late summer drought”. In these areas, e.g. parts of the North Island and the West Coast of the South Island, Douglas-fir should be given a score of 1. Evidence, that late-summer-drought situations are uncommon and good water supply is present during the summer months across the years should be prepared. Historical soil moisture deficit data during the later summer months can provide an indication for the conditions at a site. NIWA provides such data via their website, but if possible, local knowledge should also be sought to confirm that no

[1] Lodgepole pine is an unwanted organism under the Biosecurity Act. It is an offence to sell, propagate or distribute unwanted organisms, without an exemption. Land owners/managers should also consult the latest version of their regional pest management plan to confirm if other tree species are listed as a pest, which are not to be intentionally planted.

pronounced “late summer drought” prone conditions exist in the area of afforestation (Figure 4).

Altitude influences coning and seed production in most conifer species. Seed production drops off with increasing altitude, but this is species specific. Radiata pine becomes a very sporadic coner over 600-700m and cone production of Douglas-fir drops quickly over 1100 m altitude.

Indicator Two: Species Palatability

The susceptibility of a tree species to browsing by livestock is another characteristic that influences the risk of wilding spread and the survival of wildings once established (Figure 5). The more palatable conifer species are for sheep the better the results of grazing as a tool to prevent wilding establishment, especially if seedling are still young. Scoring is straightforward and palatability should be scored for each individual tree species on a site.

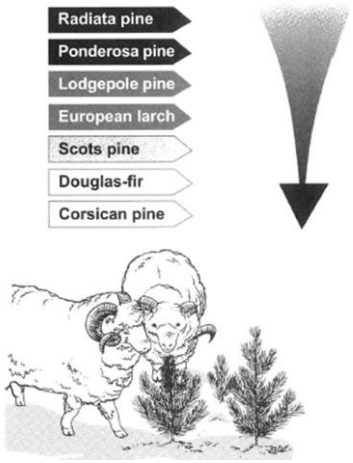


Figure 5. Radiata pine is easier grazed out than Douglas-fir as it is the most palatable species of the common introduced conifers.

Indicator Three: Siting of the new planting

The topographic position of a new forestry site relative to the prevailing wind direction is the second most critical factor behind species growth (spread vigour) in determining the intensity and distance of seed spread from planted trees. The major long distance spread direction is, in general, determined by the prevailing wind direction during late summer, autumn and early winter months, when many exotic conifers release their seed. Fringe spread can occur under all conditions and this needs to be accounted for in all afforestation projects.

It is especially important to score larger afforestation projects by identifying topographically different sites first e.g. ridges, slopes, valley bottoms and open flat sites (Figure 6). Each of the sites needs to be assessed separately as they will score differently.

The individual assessment of the topographically different sites that make up a new plantation allows better assessment and the indication of more risky sites, particularly “take off” sites that might require, for example, a change in species to reduce the overall spread risk.

Local expertise may be required to determine the main regional wind-pattern covering the proposed forest project site. If possible, local weather-stations should be identified as this can assist in the wind assessment.

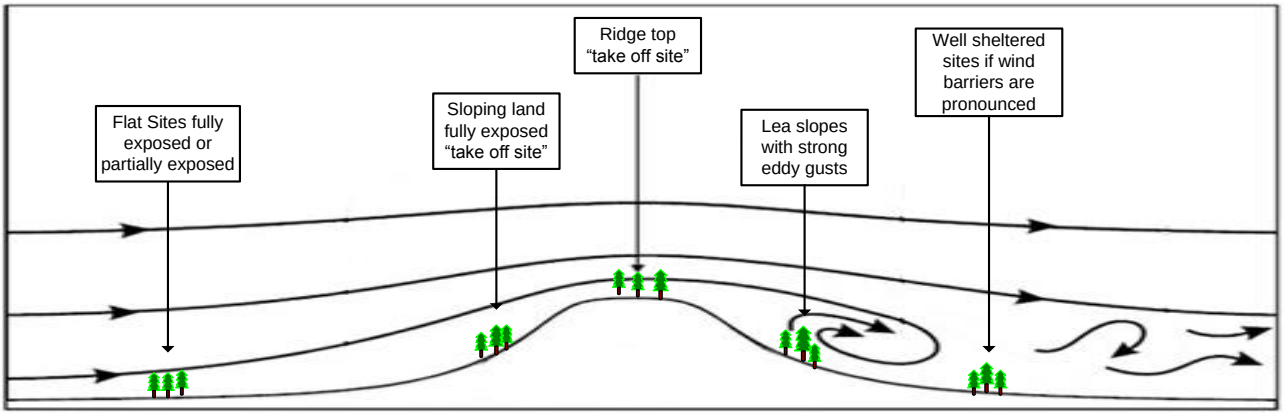


Figure 6. Simplified presentation of wind-flow over a hill, showing a range of sites with varying risk of dispersing seed

Geographic information systems can also aid the assessment, if good spatial information is available (such as terrain, slope and other relevant information). Such information based on an objective assessment of the situation would provide supporting evidence during the planning process if provided as a supplementary report.

Examples of the different site conditions listed in the Calculator (combining topography and wind direction) are given in Figures 7-10.

Sites well sheltered (Figure 7): Areas that are not exposed to the prevailing wind and usually experience calm conditions, such as valley bottoms and bases of slopes perpendicular to the wind-direction or the head of valleys. Such sites would score zero in the calculator.

Flat sites partially exposed (Figure 8): Sites that do not directly lie exposed to the prevailing wind but have only partial protection through topographic features such as hills in the immediate upwind vicinity (maximum of 1 km away). Such sites would score one in the calculator.

Lee slopes with strong eddy gusts (Figure 9): Objects such as hills or ridgelines that are exposed to the strong winds can serve as a sheltering feature in the landscape. However, wind-turbulence directly behind these features can create strong eddy gusts that can result in additional uptake of seed against the main windflow. If this is the case the area upwind might also need to be assessed for grazing and vegetation cover. Such sites would score two in the calculator.

Flat sites fully exposed (Figure 10): Many wide open river valleys and terraces can be exposed, particularly those in the South Island that are run east from the main divide. No obstructions, or only small obstructions, are characteristics of such sites. Plateaus without surrounding obstructions also fall into this category, or into the highest category of elevated take-off sites (see below). Flat sites fully exposed score three in the calculator.

Elevated "take-off" sites or sloping fully exposed land (Figures 11 & 12)
Some topographic features are especially prone to strong winds or experience high wind conditions, especially where the normal wind stream becomes "compressed". These include ridge-tops, channels and funnels on a mountain range and steeper slopes (>10°) that are exposed to the main wind direction. Such sites would score four in the calculator.

Figures 13, 14 and 15 show various plantation forest sites. Each individual topographic situation in which planted stands are found requires an individual assessment to ensure correct scoring of the siting situation. This helps to identify unsuitable sites that might need to be excluded from planting, or where a different species choice might be required.

Figure 7. Sheltered site (score 0) at the lower and mid-section of a downwind facing slope/face. Ridge area has not been planted (except radiata in background; picture taken facing upwind)

Figure 8. Large Douglas-fir stand placed on a partially exposed site (score 1). Some shelter is provided by the rolling hills in front. However, once fully grown, the tree crowns will be exposed (looking downwind).

Figure 9. Small Douglas-fir stand sheltered from prevailing wind but possibly exposed to eddy gusts (on a terrace of the Rakaia; score 2). Note: Radiata pine shelterbelts on ridge with no signs of wildings.

Figure 10. Flat and exposed afforestation site (score 3). The siting score is high for such a site (picture taken facing straight upwind).

Figure 11. Flat, fully exposed site on an old river terrace prone to very strong north-westerly winds (score 4).

Figure 12. In foreground sheltered Douglas-fir stand (wind direction from left to right; score 0). Background shows plantings far more exposed and at high risk to be a take-off site (particularly upper part facing upwind; score 4).

Figure 13. A forest with two siting conditions calling for two separate siting assessments. The upper ridge part is less suited and can be characterised as a take-off site as wind will channel strongly through this gap (wind direction slightly from the right; score 4). The lower slopes and flatter parts will score lower (score 2).

Figure 14. Multiple forest stands, representing different sites that would result in very different scores. The site on the ridge on the right upper corner would score highest as a take-off site (score 4); the right foreground shows a well sheltered stand (Score 0); the left-hand stand lies in a wind channel and would score higher (score 3 or 4); the middle stand is sheltered and set back against the main ridge (score 0). (Main wind direction from right to left.)

Figure 15. Existing forest with a wide range of different siting situations. Ridges in the background represent take-off sites and lower parts can be scored as sheltered. Note: seed from ridge plantings will mostly fall into plantation forest due to the size of forest, but the possibility for long distance dispersal exists.

Indicators Four and Five: Downwind Land Use and Vegetation Cover

Seed receiving land

"Seed-receiving" areas need to be identified for the grazing and vegetation indicators below. Assessments are required of all areas that are 200 metres or less from the intended afforestation site (accounting for "fringe spread", see glossary), and as far as two kilometres downwind once main spread direction for a site has been determined. As multiple land-uses can occur over such a large distance, an assessment of all present land use practices is required, and their proportion documented (% of land with grazing situation x and vegetation cover type y).

Downwind Land use – Grazing

Sites that will receive seed from the proposed plantings need to be assessed to determine the ability of wilding conifers to germinate and grow. The intensity and type of the grazing regime on grasslands is a critical factor as grazing can prevent the ongoing development of established seedlings. Assess the grazing situation by asking landowners about their current grazing regimes. Site assessments are also useful as they allow checks on the pasture condition, which is often linked with the grazing regime (Figure 16). The grazing situation is worth documenting in a supplementary report (if likely to be required for a consent process), and signed by the relevant parties to underpin the scoring conclusions.

Downwind Vegetation Cover

The vegetation cover needs to be determined and scored for sites that will receive seed from the proposed plantings as wilding establishment and development is influenced by competition and shading from the existing vegetation (Figures 17 – 20). Thick and dense shade-providing vegetation has a direct negative influence on wilding survival; pines in particular. Douglas-fir withstands semi-shade conditions that can occur in shrub lands and more open indigenous forest. Therefore, adjacent shrub lands and the canopy status and development of forests should be inspected closely when considering Douglas-fir plantings and findings should be incorporated in the overall assessment report.

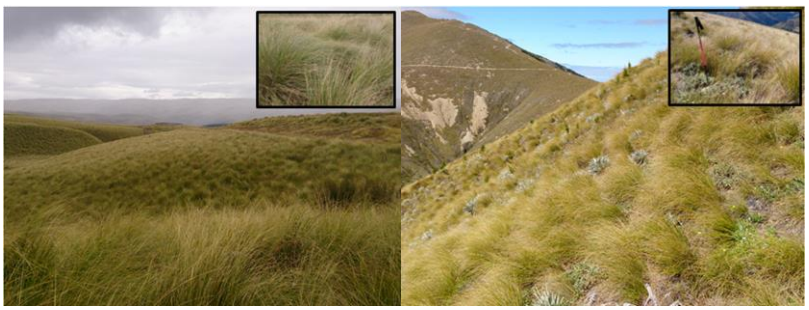


Figure 20. Density of vegetation influences the establishment probability of conifers. Dense and healthy vegetation (left) reduces the risk of wilding establishment (score 1-2). More open vegetation (right) provides better microsites for establishment (bare ground and mineral soil, score 4).

Figure 16. Difference between un-grazed (left, score 4) and lightly grazed (right) grass swaths (score 3).

Figure 17. Semi improved pasture dominated by exotic grasses and with good fertility for high country pasture (score 1).

Figure 18. Well improved pasture with thick grass swaths (score 0). Trees and shrubs have only a chance to establish themselves on small escarpments at terrace edges.

Figure 19. Short tussock grasslands with plenty of open bare soil and poor ground cover (score 3).

Calculating the risk score for an afforestation site

As most afforestation sites do not have uniform characteristics, multiple calculations may need to be undertaken. Separate assessment scores will be required, as even smaller sites may have distinct units, that diverge in topography (and therefore wind conditions), planned tree species and the downwind land conditions (vegetation and grazing situation). The risk of spread will therefore vary in each case. Covering all possible combinations of species, siting and receiving lands, will result in a range of scores for a site (as shown in Figure 21).

In its simplest form, the landowner will initially subdivide the site by the species they are proposing to plant (as each species has different spread vigour and palatability). They then divide the individual units by siting, land use and vegetation cover (as described in the indicator section). This process breaks down a proposed afforestation area into a number of discrete units, which will need to be assessed individually.

The steps in more detail, for the Douglas-fir example in Figure 21, are described below:

Step 1 and 2: Determine the species vigour and palatability scores, e.g. Douglas-fir would score 7 (a vigour score of 4 (indicator one) and a palatability score of 3 (indicator two)).

Step 3: If multiple topographic sites for a species are present separate assessments and scoring will be required (e.g. a ridge scores 4 and a lea slope would score 2)

Step 4 and 5: For each topographic site, the adjacent and downwind land use and vegetation cover will need to be determined to assess the potential risk of establishment of wildings for these seed receiving sites. This can lead to multiple receiving sites and a range of scores. Recording the area for each combination of receiving sites can help to quantify the overall risk better.

The scoring pathway for a Douglas-fir afforestation project with multiple topographic sites and a variety of receiving land-types is shown graphically in Figure 21. In this example three out of seven possible planting and siting combinations receive a high spread risk score of over twelve (based on the assessment of all combinations).

The high scores are the result of the combination of planting a high scoring conifer species (Douglas-fir) on a take-off site (ridge) and of the land-use and vegetation cover downwind from the planting. Planting a different species choice in these high risk areas (e.g. with lower vigour or increased palatability to stock) would reduce the potential for spread and the score. Other alternatives would be to consider excluding the high risk sites or modifying land-use (grazing) / vegetation management practices in the adjacent areas to reduce the risk score.

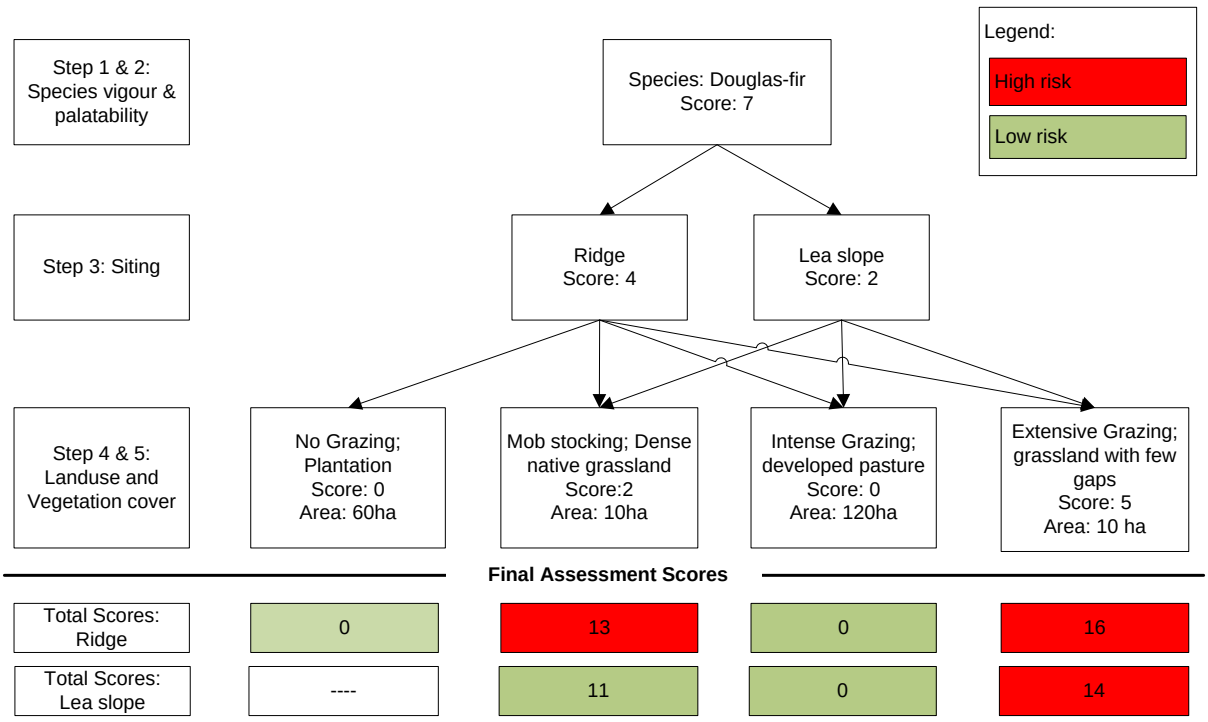
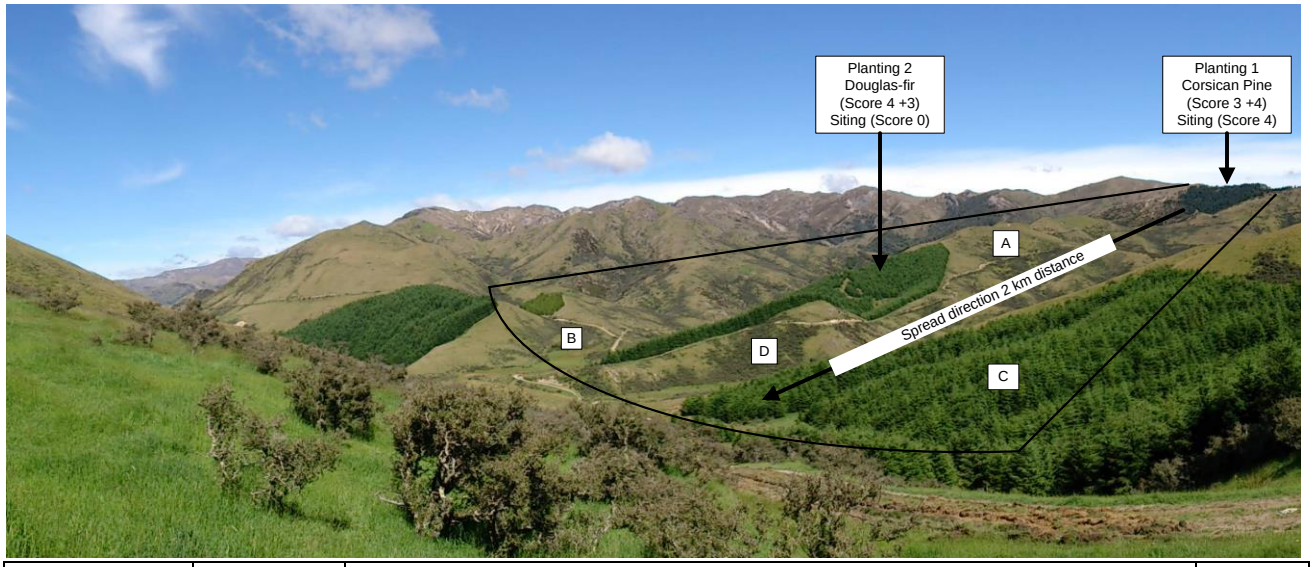


Figure 21. Assessment of a Douglas-fir afforestation on two adjacent sites. Final scores for both sites (ridge & lee slope) are given in the last two rows of the diagram. Some of the combinations (shown in red) have a high risk of wilding spread.

Assessing downwind conditions under different grazing and vegetation patterns

Figure 22 describes the assessment of downwind conditions for an existing Corsican pine (*Pinus nigra*) stand on an exposed ridge (Planting 1). This planting would score high for species (vigour = 3 and palatability = 4) and siting (ridge = 4), giving a combined score of 11. A number of land types with different grazing regimes are found downwind from the planting in an area stretching out over 2 km along the main wind direction (a "wind-fan"[2]). Each of the identified land types – a combination of the vegetation and grazing regime – need to be assessed (see the table associated with Figure 22). A large area (receiving land types A and D) is at risk of wilding establishment (score of 15 and 16 by the assessment).

If this site was a new proposal, planting Corsican pine on the ridge would pose a significant risk of spread. A different species choice, or moving the planting to a more sheltered situation (such as to planting 2), would greatly reduce the risk of wilding conifers.



Species score	Siting score	Receiving land				Score
		Area	Grazing	Vegetation	Area (%)	
Planting 1 Corsican Pine (3 + 4)	Ridge (4)	A	Semi improved (2)	Grassland improved with few gaps (2)	50	**15**
		B	Intensive grazing (0)	Developed pasture (0)	10	0
		C	No Grazing (4)	Plantation Forest (0)	30	0
		D	Extensive Grazing (3)	Shrubland with few gaps (2)	10	**16**

Figure 22: Wilding risk calculator assessment of an existing planting of Corsican pine (planting 1) in steeper hill country. Main wind direction is from the upper right.

[2] A similar assessment should be carried out around the planting for a buffer of 200m (not shown here)

Final remarks

These guidelines will help ensure the Wilding Spread Risk Calculator is applied consistently and in a standardised manner for new afforestation proposals by users including district and regional council staff, consultants, farmers and foresters. Documenting and clearly outlining the individual required steps and their results will help the interpretation and understanding of how scores have been derived. This creates the basis for further discussions, potential mitigation steps and the final agreement on the status of individual afforestation sites, e.g. will a consent application be necessary and is there a need to impose consent conditions.

Glossary

Afforestation: The intentional planting or seeding of trees, mostly for gaining timber or wood-products or possibly other environmental benefits like wind shelter, reducing soil erosion or waterway protection.

Discretionary activity: a resource consent is required for the activity and (a)the consent authority may decline the consent or grant the consent with or without conditions; and (b) if granted, the activity must comply with the requirements, conditions, and permissions, if any, specified in the Act, regulations, plan, or proposed plan.

Fringe Spread: In general most seed falls close to the parent tree resulting in wilding conifers close to stand boundaries and forest edges. Such close seed fall can occur along any stand edge independent to the main wind direction and up to a distance of 200m (Ledgard, et al., 1999). Therefore fringe spread need to be assessed in a buffer of 200m around any intended planting site.

Long Distance Spread: Seed can be transported under certain wind condition over long distances (rarely over 5 km). To account for these events, assessments should be carried out to a distance of 2 km.

Outlier trees: Wilding conifers that are the result of distant spread, often from seed sourced from take-off sites, occurring very scattered across the landscape.

Permitted activity: A resource consent is not required for the activity if it complies with the requirements, conditions, and permissions, if any, specified in the Act, regulations, plan, or proposed plan.

Restricted discretionary activity: A resource consent is required for the activity and (a) the consent authority's power to decline a consent, or to grant a consent and to impose conditions on the consent, is restricted to the matters over which discretion is restricted (whether in its plan or proposed plan, a national environmental standard, or otherwise); and (b) if granted, the activity must comply with the requirements, conditions, and permissions, if any, specified in the Act, regulations, plan, or proposed plan.

Site: Parcel of land that is relatively homogenous in its topography and environmental conditions. For practical reasons this can be assessed on a scale of 1 hectare as the smallest unit.

Take off site: Ridges and slopes exposed to the prevailing winds, from where seed can be blown considerable distances and give rise to scattered outlier trees.

Wilding conifer: Self-established exotic conifers, resulting from seed spread from plantations, shelterbelts, amenity plantings or already established wilding conifer populations.

References

Ledgard, N. J., & Langer, L. (1999). Wilding Prevention - Guidelines for minimising the risk of unwanted wilding spread from new plantings of introduced conifers. In Research, F. (Ed.): New Zealand Forest Research Institute Limited.

Appendix One – Field form of the DSS1

DSS 1. CALCULATING WILDING SPREAD RISK FROM NEW PLANTINGS [a,b]

(Select score applicable for each of the five categories)

Version_07011; Issue date: June 2012

1. SPECIES – GROWTH *(score for one species only)*

Spreading vigour varies with species

- Redwoods, Leyland cypresses, cedars and spruces (very low risk – no need to proceed further) 0
- Radiata (*P. radiata*) and ponderosa (*P. ponderosa*) pine, Lawsons cypress (*C. lawsoniana*) 1
- Muricata (P. *muricata*) and maritime (*P. pinaster*) pine and larches (*Larix* spp) 2
- Corsican (*P. nigra*) and mountain/dwarf mountain (*P. uncinata/mugo*) pine 3
- Douglas-fir [g] (*Ps. menziesii*), Scots pine (*P. sylvestris*) 4 [g]
- Lodgepole/contorta pine (*P. contorta*) 5

Enter score (0, 1, 2, 3, 4 or 5) here ☐

2. SPECIES – PALATABILITY

Palatability varies with species

- Radiata, maritime and ponderosa pine 1
- Lodgepole and muricata pine and European larch 2
- Scots and mountain/dwarf mountain pine and Douglas-fir 3
- Corsican pine 4

Enter score (0, 1, 2, 3 or 4) here ☐

3. SITING OF NEW PLANTING [c, d]

Trees are located on ….

- Sites well sheltered from prevalent and strong winds 0
- Flat sites (<10^0), partially exposed to strong/prevalent winds 1
- Lea slopes where strong eddy gusts are likely 2
- Flat sites (<10^0), fully exposed to strong/prevalent winds 3
- *Either* elevated 'take-off' sites, (ridge-tops, or base of exposed slopes >10^0) 4
  or sloping land, fully exposed to strong/prevalent winds

Enter score (0, 1, 2, 3 or 4) here ☐

4. DOWNWIND LANDUSE – GRAZING

Wilding establishment influenced by grazing (particularly with sheep)

- Intensive grazing on developed pasture 0[d]
- Regular mob stocking with sheep [e] 1[d]
- Semi-improved grazing (sheep/cattle)/ occasional mob stocking with sheep 2[d]
- Extensive grazing only [e] 3[d]
- No grazing 4[d]

Enter score (0, 1, 2, 3 or 4) here ☐[d]

5. DOWNWIND VEGETATION COVER *(if Douglas-fir involved see [g] in Notes)*

Wilding establishment influenced by competition from existing vegetation

- Plantation forest, developed pasture (intensive grazing) 0[d]
- Native forest[h], shrubland/tussock/grassland with a continuous and dense vegetation cover 1[d]
- Forest/shrubland/tussock/grassland with few gaps 2[d]
- Open forest and/or scattered patches of dense shrubland/tussock/grassland with many gaps 3[d]
- Open slips/rockland and/or light, low-stature shrubland/tussock/grassland 4[d]

Enter score (0, 1, 2, 3 or 4) here ☐[d]

TOTAL SCORE ☐

(See Assessment below for interpretation)

ASSESSMENT

- A score of **12** or more indicates a high risk of spread from the planted site.
- BUT, if a score of '0' is obtained in 1. SPECIES – GROWTH, or 4. DOWNWIND LANDUSE – GRAZING, or 5. DOWNWIND VEGETATION COVER, the total score automatically becomes '0' (ie., there is no risk of wilding spread). Although, note the need to test long distance spread risk from exposed sites (scoring 3 or 4 in 3 - Siting)

A high risk does not necessarily mean that trees should not be planted. A change of species, or siting, or downwind land management can significantly lower spread risk. Conversely, a change of species when replanting after harvesting might increase spread risk. If there is a risk of wilding spread, then a commitment to wilding removal should be made - this may not be onerous, particularly for scattered trees (often outliers from distant spread).

NOTES:

[a] **Multiple calculations.** As the above score sheet indicates, there are a range of factors influencing the risk of spread. The impact of these will vary from site to site, both within a single forest and on the surrounding land. Therefore, spread risk will need to be calculated not just once, but a number of times in order to accommodate the range of sites represented within and outside the forest.

[b] **Risk assessment location**. This DSS was compiled primarily for use in the drier hill and high country areas of the eastern South Island, where low-stature grasslands (and to a lesser extent, shrublands) often dominate, and where opportunities for wilding establishment are greatest. Wilding spread risk is considerably less in the warmer, wetter parts of New Zealand (mostly present in the North Island), due to higher-stature vegetation covers being more vigorous and complete, and to poorer seed production in some species (such as Douglas-fir).

[c] **Altitude.** The coning ability of some species drops off quickly with increasing altitude. Contorta and mountain pine will readily establish and cone above native treeline. Scots pine and Douglas-fir will establish at tree line. Corsican pine and Douglas-fir coning drops off quickly above 800 and 1100 m respectively – the limit for Scots pine coning is unknown. Radiata pine is a reluctant spreader above 6-700 m, except on the warmer sites. The altitudinal establishment and coning limits for muricata pine and larch are unknown.

[d] **Long distance spread.** This is quite possible if a score of 3 or 4 is scored in 'Siting' (in 3) especially if Douglas-fir, larch or Corsican, contorta, mountain or Scots pines are involved (all have light seed which is readily dispersed greater distances by wind). In these circumstances, the risk of spread relative to grazing (4) and vegetation cover (5) needs to be scored out to beyond the 'fringe' area, to a distance of 2 km. ('Fringe' infers a distance from seed source of 1 – 200m)

[e] **Regular mob stocking**. If the pasture is only semi-improved and the seed rain is heavy, such as alongside mature conifers (particularly Corsican pine – the least palatable conifer), regular mob stocking may not prevent wilding establishment over the long term.

[f] **Light grazing.** This will reduce wilding establishment, but given enough time, some wildings will eventually grow to above browse height. Palatability of introduced conifers is (in decreasing order): radiata > ponderosa > contorta > larch > Scots pine > Douglas fir > Corsican pine.

[g] **Douglas-fir.** i) This species is more shade tolerant than the other common conifers. Therefore, it is more likely to invade under forest canopy gaps and within low-stature (<2m tall) shrublands.

ii) Douglas-fir requires some drought stress during bud formation in late summer to ensure cone buds are formed in the following season; otherwise they become vegetative buds. Hence, coning is significantly less in moister (and often warmer) parts of NZ (eg., much of N. Island, west coast of S. Island). *Therefore, in these areas , Douglas-fir should be given a score of '1' (not '4') in 'SPECIES – GROWTH'.*

[h] **Native forests .v. plantations of introduced trees**. Man-made plantations are much more likely to have a continuous canopy cover, than are existing native forests, where disturbance and canopy gaps are a normal part of the natural succession cycle.